Grant Lake Hydroelectric Project (FERC No. 13212)

Water Resources Study –
Water Quality, Temperature and Hydrology
Final Report

Prepared for
Kenai Hydro, LLC

Prepared by
C. Sauvageau and A. Scott
McMillen, LLC

June 2014

TABLE OF CONTENTS

Appendices

List of Tables

List of Figures

Acronyms and Abbreviations

ADCP	Acoustic Doppler Current Profiler
ADEC	Alaska Department of Environmental Conservation
AEIDC	Arctic Environmental Information Data Center
CFR	Code of Federal Regulations
DLA	Draft License Application
EPA	Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
KHL	Kenai Hydro, LLC
LA	License Application
MW	megawatt
NAVD 88	North American Vertical Datum of 1988
NGVD 29	National Geodetic Vertical Datum of 1929
NOI	Notice of Intent
NTU	Nephelometric Turbidity Units
ORP	oxygen reduction potential
PAD	Pre-Application Document
PM&E	protection, mitigation and enhancement
Project	Grant Lake Hydroelectric Project
QA	quality assurance
RPD	Relative Percent Difference
TLN	Trail Lake Narrows
TBM	temporary benchmark
USFS	U.S. Department of Agriculture, Forest Service
USGS	U.S. Department of the Interior, Geological Survey

[This page intentionally left blank.]

Water Resources Study – Water Quality, Temperature, and Hydrology Final Report Grant Lake Hydroelectric Project (FERC No. 13212)

1 INTRODUCTION

On August 6, 2009, Kenai Hydro, LLC (KHL) filed a Pre-Application Document (PAD; KHL 2009), along with a Notice of Intent (NOI) to file an application for an original license, for a combined Grant Lake/Falls Creek Project (Federal Energy Regulatory Commission [FERC] No. 13211/13212 ["Project" or "Grant Lake Project"]) under Part I of the Federal Power Act (FPA). On September 15, 2009, FERC approved the use of the Traditional Licensing Process (TLP) for development of the License Application (LA) and supporting materials. As described in more detail below, the proposed Project has been modified to eliminate the diversion of water from Falls Creek to Grant Lake. The Project will be located near the community of Moose Pass, Alaska in the Kenai Peninsula Borough, approximately 25 miles north of Seward, Alaska and just east of the Seward Highway (State Route 9).

The Water Resources Study Plan was designed to address information needs identified in the PAD, during the TLP public comment process, and through early scoping conducted by FERC. The following study report presents existing information relative to the scope and context of potential effects of the Project. This information will be used to analyze Project impacts and propose protection, mitigation, and enhancement measures in the draft and final LA's for the Project.

The Project is located near the community of Moose Pass, approximately 25 miles north of Seward and just east of the Seward Highway. It lies within Section 13 of Township 4 North, Range 1 West; Sections 1, 2, 5, 6, 7, and 18 of Township 4 North, Range 1 East; and Sections 27, 28, 29, 31, 32, 33, 34, 35, and 36 of Township 5 North, Range 1 East, Seward Meridian (U.S. Geological Survey [USGS] Seward B-6 and B-7 Quadrangles).

The proposed Project would be composed of an intake structure at the outlet to Grant Lake, a tunnel, a surge tank, a penstock, and a powerhouse. It would also include a tailrace detention pond, a switchyard with disconnect switch and step-up transformer, and an overhead or underground transmission line. The preferred alternative would use approximately 15,900 acre-feet of water storage during operations between pool elevations of approximately 692 and up to 703 feet North American Vertical Datum of 1988 (NAVD 88)[1].

[1] The elevations provided in previous licensing and source documents are referenced to feet mean sea level in NGVD 29 [National Geodetic Vertical Datum of 1929] datum, a historical survey datum. The elevations presented in the Grant Lake natural resources study reports are referenced to feet NAVD 88 datum, which results in an approximate +5-foot conversion to the NGVD 29 elevation values.

An intake structure would be constructed approximately 500 feet east of the natural outlet of Grant Lake. An approximate 3,200-foot-long, 10-foot diameter horseshoe tunnel would convey water from the intake to directly above the powerhouse at about elevation 628 feet NAVD 88. At the outlet to the tunnel a 360-foot-long section of penstock will convey water to the powerhouse located at about elevation 531 feet NAVD 88. An off-stream detention pond will be created to provide a storage reservoir for flows generated during the rare instance when the units being used for emergency spinning reserve are needed to provide full load at maximum ramping rates. The tailrace would be located in order to minimize impacts to fish habitat by returning flows to Grant Creek upstream of the most productive fish habitat.

Two concepts are currently being evaluated for water control at the outlet of Grant Lake. The first option would consist of a natural lake outlet that would provide control of flows out of Grant Lake. A new low level outlet would be constructed on the south side of the natural outlet to release any required environmental flows when the lake is drawdown below the natural outlet level. The outlet works would consist of a 48-inch diameter pipe extending back into Grant Lake, a gate house, regulating gate, controls and associated monitoring equipment. The outlet would discharge into Grant Creek immediately below the natural lake outlet.

In the second option, a concrete gravity diversion structure would be constructed near the outlet of Grant Lake. The gravity diversion structure would raise the pool level by a maximum height of approximately 2 feet (from 703 to 705 feet NAVD 88), and the structure would have an overall width of approximately 120 feet. The center 60 feet of the structure would have an uncontrolled spillway section with a crest elevation at approximately 705 feet NAVD 88. Similar to the first option, a low level outlet would be constructed on the south side of the natural outlet to release any required environmental flows when the lake is drawn down below the natural outlet level. The outlet works would consist of a 48-inch diameter pipe extending back into Grant Lake, a gate house a regulating gate, controls, and associated monitoring equipment. The outlet would discharge into Grant Creek immediately below the diversion structure.

Figure 1.0-1 displays the global natural resources study area for the efforts undertaken in 2013 and 2014 along with the likely location of Project infrastructure and detail related to land ownership in and near the Project area. Further discussions related to specifics of the aforementioned Project infrastructure along with the need and/or feasibility of the diversion dam will take place with stakeholders in 2014 concurrent with the engineering feasibility work for the Project. Refined Project design information will be detailed in both the Draft License Application (DLA) and any other ancillary engineering documents related to Project development. The current design includes two Francis turbine generators with a combined rated capacity of approximately 5.0 megawatts (MW) with a total design flow of 385 cubic feet per second. Additional information about the Project can be found on the Project website: http://www.kenaihydro.com/index.php.

Upper Trail Lake

Moose Pass

Grant Lake

Diversion

Intake

Access Road

Grant Creek

Intake Access Road

Tunnel

Penstock

Pond Outlet

Power House

Detention Pond

Lower Trail Lake

Vagt Lake

Legend

- Alaska Railroad
- Seward Highway

Land Ownership

- ARRC
- BLM
- BOROUGH
- PRIVATE
- STATE
- USFS
- Study Area

MAP NOTES:

1. THIS MAP WAS DEVELOPED FOR KENAI HYDRO, LLC AS PART OF THE GRANT LAKE HYDROELECTRIC PROJECT (FERC NO. 13212), NATURAL RESOURCES STUDY DOCUMENTATION. THE LOCATION OF PROJECT FEATURES IS SUBJECT TO CHANGE AND IS SHOWN FOR PLANNING PURPOSES ONLY.
2. THIS MAP WAS DEVELOPED FROM THE FOLLOWING RESOURCES:
   A. AERIAL IMAGERY DEVELOPED BY USFS.
   B. PROJECT FEATURE LOCATIONS PROVIDED BY KENAI HYDRO, LLC.
   C. LAND OWNDERSHIP BOUNDARIES PROVIDED BY THE KENAI PENINSULA BOROUGH'S GIS DEPARTMENT.
3. THIS MAP PRESENTS DATA IN THE FOLLOWING GEOGRAHIC SYSTEMS:
   - HORIZONTAL DATUM: NORTH AMERICAN DATUM 1983 (NAD 83)
   - VERTICAL DATUM: NORTH AMERICAN VERTICAL DATUM 1988 (NAVD 88)
   - PROJECTION: ALASKA 4 FIPS 5004 FEET STATE PLANE

REV	DATE	BY	DESCRIPTION

N

Drawing Scale:

0 0.25 0.5 1 Miles

McMILLEN, LLC

THE BONNI BUILDING
910 MAIN ST, SUITE 258
BOISE, ID 83702

OFFICE: 208.342.4214
FAX: 208.342.4218

Developed For:

Homer Electric Association, Inc.

A Touchstone Energy® Cooperative

GRANT LAKE HYDROELECTRIC PROJECT - FERC PROJECT #P-13212

GRANT LAKE NATURAL RESOURCES STUDY

Figure 1.0-1
Natural Resources Study Area

DESIGNED: Jake Woodbury
DRAWN: Jake Woodbury
CHECKED: C. Warnock
ISSUED DATE: 1/9/2014

DRAWING

SCALE: 1:27,000

2 STUDY OBJECTIVES

Together with existing information, the goal of the Water Resources Study effort was to provide baseline information, and where applicable, information on alternative flow regimes, which will inform an assessment of potential Project impacts on water resources. The impact assessments and potential protection, mitigation, and enhancement measures will be presented in the draft and final LAs.

The goals of this suite of studies were to provide supporting information on the potential resource impacts of the proposed Project that were identified during development of the PAD, public comment, and FERC scoping for the LA, as follows:

- Impact of Project construction and operation (lake level fluctuations, changes in flow) on Grant Lake and Grant Creek water quality, hydrology, and water temperature.
- Impact of Project construction and operation on water quality of Lower Trail Lake and Trail Creek.

Specific study objectives and quantitative objectives are presented below for each individual study component.

2.1. Water Quality and Temperature

Water quality studies were conducted to further document baseline conditions in Grant Lake, Grant Creek and Trail Lake Narrows. Describing the baseline conditions in each of these systems is necessary for understanding how Project operations may affect water quality. Water quality parameters were chosen for analysis based on several factors: parameters sampled in previous studies, parameters that may be affected by land use practices in the Project area, and fresh water criteria that have been developed by the Alaska Department of Environmental Conservation (ADEC) for the growth and propagation of fish, shellfish, other aquatic life, and wildlife.

Temperature monitoring was conducted to further document baseline conditions in Grant Lake and Grant Creek prior to any Project activities. Obtaining baseline information on the seasonal temperature regime was necessary to provide data necessary to assess potential Project impacts to stream temperatures under various operational scenarios. These temperature data are also necessary to provide input data required for the planning of mitigation measures.

2.2. Hydrology

Hydrology studies were conducted in order to further document baseline flow conditions in Grant Lake and Grant Creek. Describing the baseline conditions in each of these systems is necessary for understanding how alterations to seasonal flow regimes might affect aquatic resources. Results will be used in conjunction with historical data to support the concurrently conducted instream flow study, the engineering feasibility effort, and other related studies. A major goal for the study was to establish, calibrate, and maintain a rating curve at the historical U.S. Department of the Interior, Geological Survey (USGS) Station currently referred to as

GC200. Another goal was to determine if Grant Creek gains or loses water within the Canyon Reach (Reaches 5 and 6). To meet these goals, the study had two components as follows:

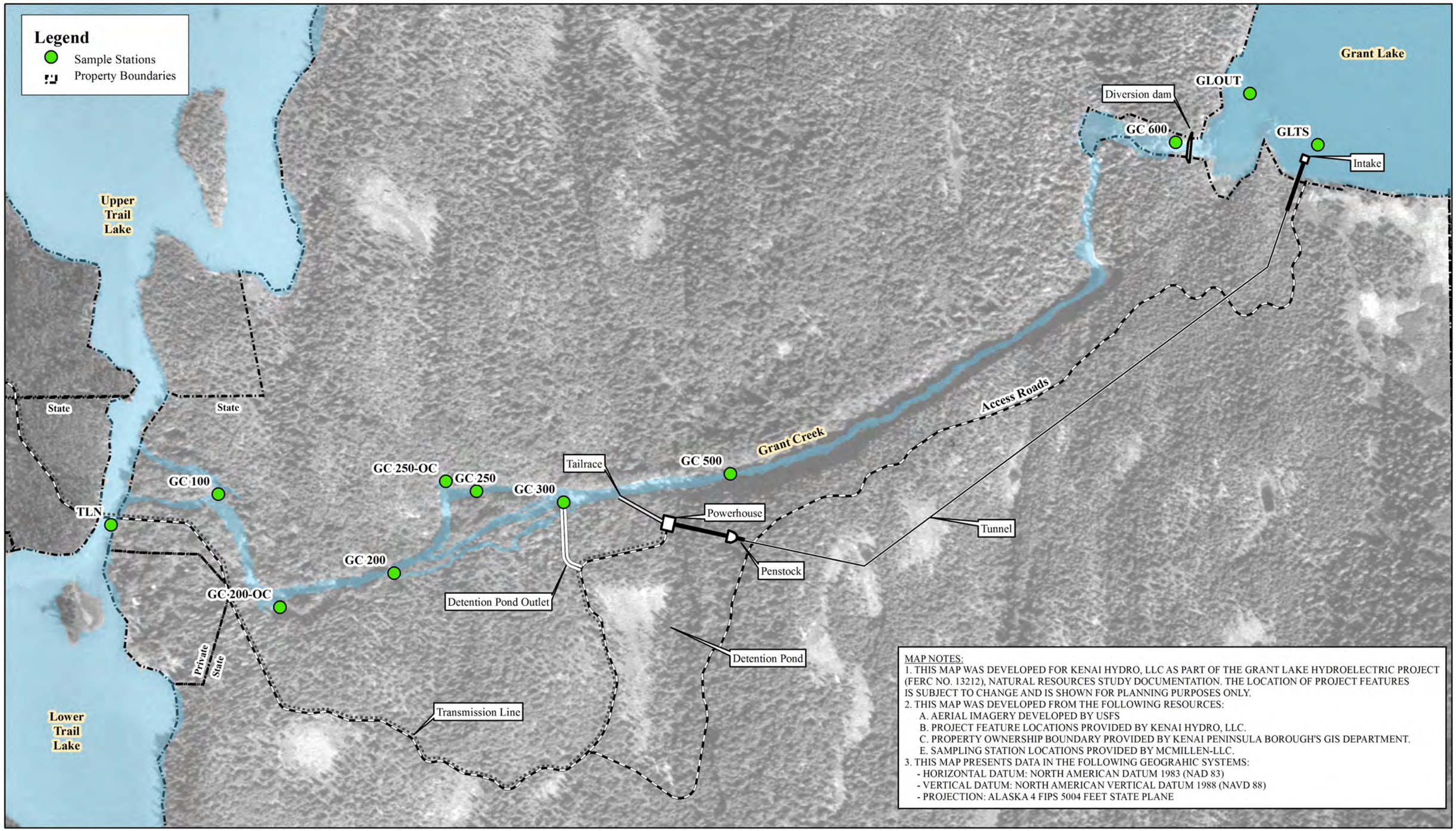
- Installation of staff gage and continuously recording stage recorder at the historical USGS gage station on Grant Creek (GC200). Continue discharge measurements at GC 200 to generate and validate an updated rating curve and extend the stream flow period of record.
- Take discharge measurements at Grant Lake outlet and near the proposed powerhouse location during stable, low-flow conditions to determine if Grant Creek gains or loses water with in the Canyon Reach.
- Provide input data required for the planning of mitigation measures.

3 STUDY AREA

The Project area is located near the town of Moose Pass, Alaska (pop. 206), approximately 25 miles north of Seward, Alaska (pop. 3,016), just east of the Seward Highway (State Route 9); this highway connects Anchorage (pop. 279,671) to Seward. The Alaska Railroad parallels the route of the Seward Highway and is also adjacent to the Project area. The town of Cooper Landing is located 24 miles to the northwest and is accessible via the Sterling Highway (State Route 1), which connects to the Seward Highway approximately 10 miles northwest of Moose Pass.

Grant Creek is approximately 5,180 feet long (approximately one mile) and flows west from the outlet of Grant Lake to the narrows between Upper and Lower Trail lakes (Figure 3.1-1). The Grant Creek watershed is approximately 44 square miles and the watershed contains Grant Lake as well as a portion of the Kenai Mountain Range with glacier capped peaks as high as 5,500 feet. Grant Creek has a mean annual flow of 193 cfs, with an average gradient of 207 feet per mile; its substrate includes cobble and boulder alluvial deposits and gravel shoals (Ebasco 1984). The stream is 25 feet wide, on average. In its upper half, the stream passes through a rocky gorge with three substantial waterfalls; in its lower half, the stream becomes less turbulent as it passes over gravel shoals and diminishing boulder substrate (Ebasco 1984). Grant Creek's mobile substrate is comprised of well packed, unsorted broken angular rock, and there is minimal rounded material. Some fines may be found in small eddies and a few backwaters.

Inlet Creek is the predominant stream in the upper portion of the watershed and drains melting alpine glaciers and snow from the nearby mountains into Grant Lake on the eastern banks. Grant Lake itself sits in the lower portion of the watershed. Grant Lake encompasses two almost separate bathymetric lake basins, which are separated by a shallow submerged ridge at the "narrows" that connects the two basins at right angles (Ebasco 1984). The deepest point within the lower basin is approximately 262 feet deep and the upper basin is 283 feet deep (Ebasco 1984).



MAP NOTES:
1. THIS MAP WAS DEVELOPED FOR KENAI HYDRO, LLC AS PART OF THE GRANT LAKE HYDROELECTRIC PROJECT (FERC NO. 13212), NATURAL RESOURCES STUDY DOCUMENTATION. THE LOCATION OF PROJECT FEATURES IS SUBJECT TO CHANGE AND IS SHOWN FOR PLANNING PURPOSES ONLY.
2. THIS MAP WAS DEVELOPED FROM THE FOLLOWING RESOURCES:
   A. AERIAL IMAGERY DEVELOPED BY USFS
   B. PROJECT FEATURE LOCATIONS PROVIDED BY KENAI HYDRO, LLC.
   C. PROPERTY OWNERSHIP BOUNDARY PROVIDED BY KENAI PENINSULA BOROUGH'S GIS DEPARTMENT.
   E. SAMPLING STATION LOCATIONS PROVIDED BY MCMILLEN-LLC.
3. THIS MAP PRESENTS DATA IN THE FOLLOWING GEOGRAHIC SYSTEMS:
   - HORIZONTAL DATUM: NORTH AMERICAN DATUM 1983 (NAD 83)
   - VERTICAL DATUM: NORTH AMERICAN VERTICAL DATUM 1988 (NAVD 88)
   - PROJECTION: ALASKA 4 FIPS 5004 FEET STATE PLANE

REV	DATE	BY	DESCRIPTION

N

Drawing Scale:
0 100 200 400 600 800 Feet

McMILLEN, LLC
1401 SHORELINE DRIVE
BOISE, ID 83702
OFFICE: 208.342.4214
FAX: 208.342.4215

Developed For:
Homer Electric Association, Inc.
A Touchstone Energy® Cooperative

GRANT LAKE HYDROELECTRIC PROJECT - FERC PROJECT NO. 13212

GRANT LAKE NATURAL RESOURCES STUDY

Figure 3.1-1
Water Quality, Temperature, and Hydrology Study Locations - 2013

DESIGNED: J. Woodbury
DRAWN: J. Woodbury
CHECKED: C. Sauvageau
ISSUED DATE: 1/9/2014

DRAWING

SCALE: 1:4,522

4 METHODS

4.1. Water Quality and Temperature

Water Quality

The field methods were designed to document current water quality conditions at selected locations and depths within Grant Lake, Grant Creek and Trail Lake Narrows (Figure 3.1-1). Two sites were sampled in Grant Lake (GLTS and GLOut); three sites in Grant Creek (GC100, GC200, GC300); and one site in Trail Lake Narrows (TLN). Sampling frequencies varied for each site and included sampling one sampling event in August for the Grant Lake and Grant Creek sites and three sampling events (June, August and September) for the Trail Lake Narrows site. Parameters sampled at these study locations as well as ADEC criteria are specified in Table 4.1-1.

Sampling was conducted at a single depth of approximately 1.0 meter at all creek sites and at an approximate depth of 1.8 meters in Trail Lake Narrows. Grab samples were taken for lab analyses with a van dorn style sampler from a well mixed portion of the stream and Narrows sites. The same van dorn style sampler was used at lake sites Samples were collected at the surface (>1 meter) and mid-level depths at the GLOut site and surface, middle and bottom (>1 meter off substrate) depths at the GLTS site. *In situ* sampling was done using a Hydrolab® MiniSonde 5 multi-parameter probe at all sites. *In situ* sampling was done at a depth of approximately 1.5 meters on Grant Creek and at Trail Lake Narrows. The Grant Lake *in situ* sampling was conducted on a vertical transect at one meter increments from the surface to the bottom of the water column.

Table 4.1-1. Water quality parameters sampled in Grant Lake, Grant Creek and Trail Lakes Narrows, CY 2013.

Parameter	Units	ADEC Water Quality Standards*
Alkalinity ($CaCO_3$)	mg/L	no criteria
Total dissolved solids (TDS)	mg/L	≤ 1000 mg/l
Total suspended sediment (TSS)	mg/L	no criteria
Kjeldahl Nitrogen	mg/L	no criteria
Nitrate/Nitrite	mg/L	10 mg/l
Orthophosphate	mg/L	no criteria
Total phosphorous	mg/L	no criteria
Lead	µg/L	16.4 µg/l (acute); 0.64 µg/l (chronic)
Hardness	mg/L	no criteria
Calcium	mg/L	no criteria
Magnesium	mg/L	no criteria
Sodium	mg/L	<2.55 mg/l
Potassium	mg/L	no criteria
Low level mercury	µg/L	1.4 µg/l (acute); 0.77 µg/l (chronic)
Fluoride	mg/L	no criteria
Chloride	mg/L	860 mg/l (acute); 230 mg/l (chronic)
Sulfate	mg/L	no criteria
pH	S.U.	≥6.5 to ≤8.5
Temperature	°C	May not exceed 20°C at any time; maximum temperatures may not exceed, where applicable: migration routes: ≤15°C; spawning areas: ≤13°C; rearing areas: ≤ 15°C; egg/fry incubation: ≤13°C.
Dissolved oxygen (DO)	mg/L	>7mg/l and <17 mg/l in waters used by anadromous fish; >5mg/l and <17 mg/l for waters not used by anadromous fish
Specific Conductivity	mS/cm	no criteria
Oxygen Reduction Potential (ORP)	mV	no criteria
Turbidity	NTU	Not to exceed 25 NTU above natural conditions. For all lake waters, may not exceed 5 NTU above natural conditions.
* Based on the following water use class/subclass: (1) fresh water/(C) growth and propagation of fish, shellfish, other aquatic life, and wildlife		

4.1.1. Sampling Procedure

Every attempt was made to adhere to the following sampling procedures during collection of all samples. These procedures included:

- Calibrate multi-probe per manufacturer's instructions before every field visit.
- Multi-probe data collection was recorded in a hand held data storage device as well as written as field notes from instantaneous readings in the field. To insure the best accuracy of the *in situ* sampling and to alleviate concerns during past sampling efforts, two multi-probe units were deployed at each site and the results were compared and averaged.
- For grab sample water collections, all sample bottles were labeled with the specific parameter, date, and location.
- Samples were collected from the actively flowing channel at stream sites into the van dorn style sampler and then transferred to laboratory-supplied bottles. The sampler was flushed with onsite stream water from each site prior to collection. Field personnel approached the site and remained downstream of the sampling point to avoid disturbing stream sediments.
- Sampling work was done from a boat at both lake sites. Grab sample locations were located and identified with a hand-held GPS.
- Lake grab samples were collected using a van dorn style collector to obtain vertical individual water samples at preselected depths for both sites.
- All samples (stream and lake) were placed on ice as soon as possible after collection and delivered to the laboratory within the approved holding time constraints.

4.1.2. Field Sampling Quality Assurance Procedures

Field sampling quality assurance (QA) ensured that field procedures produced high quality data, with 5 to 10 percent of sampling efforts commonly dedicated to QA. Field duplicates were used. A field duplicate consisted of a second sample collected immediately after the initial sample in the field. The field duplicate assessed variability in lab results that may be attributed to collection and/or lab analytical errors. All samples examined using the QA duplicate assessment method fell within the analytical lab's acceptable Relative Percent Difference (RPD) of +/- 20 percent.

Field duplicates were taken during two of the three field visits for surface water quality grab samples, both time at the Trail Lake Narrows site. Lab analysis was done by SGS North America Inc. (SGS) located in Anchorage, Alaska. SGS provided all sampling bottles with the appropriate preservation techniques (e.g., acid preservation) for individual parameters, specified appropriate quantities of water needed for all of the analyses, and conducted the analyses. Grab sample protocol was utilized for each water quality sampling event. In the field, all water samples were labeled, preserved if necessary, placed on ice and transported to SGS's Anchorage lab. The laboratory analyzed all samples and field duplicates for parameters listed in Table 4.1-1 except for the flowing *in situ* parameters: 1) temperature, 2) dissolved oxygen, 3) specific conductance, and 4) oxygen reduction potential (ORP). Turbidity and pH were measured both in the field and by the lab. Chain-of-custody forms were used during each sampling trip to

document all field, delivery, and laboratory personnel handling sample containers. Samples were analyzed within the Environmental Protection Agency (EPA) recommended holding times.

Temperature

Stream temperature data loggers were re-established at four previously monitored sites (GC 100, GC 200, GC 250, and GC 300) on Grant Creek (HDR 2000 and 2010). Two additional temperature data loggers were also established within the upper and lower canyon reach of Grant Creek (GC 500 and GC 600) as well as at two off-channel locations (GC 200-oc and GC 250-oc) where rearing salmonids were observed (Figure 3.1-1). The historical continuous temperature monitoring site in Grant Lake (GLTS) was also re-established. HOBO® Water Temp Pro v2 (ModelU22-001) temperature loggers were installed at all stream and lake locations to continuously monitor temperature in 2013. The HOBO Pro V2 logging thermistor has an operating range of -40 to 50 ºC, and is accurate to 0.2 ºC over 5 0 ºC. At the eight Grant Creek locations, each logger was placed in weighted, protective housings on the bottom of the channel and safeguarded by cables attached to shoreline trees. At the Grant Lake site, a thermistor string was installed in June 2013 along a vertical transect to a depth of 20 meters. HOBO® Pro v2 data loggers were attached to the string at ten distinct sampling depths of 0.2, 0.5, 1.5, 3.0, 6.0, 9.0, 12.0, 15.0, 18.0 and 19.5 meters. All data loggers were set to record temperature at 1-hour intervals.

Water temperatures were monitored from early April through late September 2013. Continuous temperature monitoring at all sites will continue through the 2013-2014 winter. Thermistor downloads will be conducted in the late spring or summer of 2014. This supplemental data documenting the winter period will be distributed to stakeholders and included in the Water Resources portion of Exhibit E in the LA.

4.2. Hydrology

Following guidelines from previously permitted installation activities, a stream gaging station was installed at GC 200 that consisted of a staff gage and a continuous stage data logger. Each stage measurement device was individually anchored to the stream bank and near the shoreline to avoid catching floating debris. The primary data logger used for this study was a USGS-approved bubbler/pressure transducer system manufactured by Design Analysis Associates, Inc. rated to an accuracy of 0.02 percent. Two Onset® U20-001-04 level loggers (accuracy of 0.075 percent) were also installed to serve as a secondary stage recording system. Onset® level loggers are non-vented devices, and therefore must also record barometric pressure to accurately track changes in water levels. Both of these data loggers accurately recorded pressure, which were then related to the water surface elevation of the staff gage. The data loggers were set to record water depth at 15-minute intervals.

The staff gage was mounted vertically in the stream channel to measure water depth for the full range of flow conditions. The Design Analysis data logger was housed in a shoreline enclosure with the bubbler line protected in conduit and 2”galvanized pipe within the wetted channel. The in-channel Onset® level logger was attached to the staff gage and housed in 2” ABS pipe for protection and to attenuate fluctuations in water surface elevations. The Onset® level logger needed for barometric compensations was stored in the USGS gaging house adjacent to the

shoreline. Figure 4.1-1 shows multiple views of the gage enclosure, data logger, bubbler line, and staff gage installation.

Figure 4.1-1. GC 200 enclosure, data logger, bubbler line, and staff gage installation.

During field visits, manual readings of the staff gages and the time were recorded. These manual staff gage readings were compared with the stage values provided by the data logger during the same time interval.

A differential survey was performed for each of the data loggers and the staff gage to check on vertical stability during gage operation. A cross sectional survey of the channel at the gage location was also conducted in April 2013. Multiple temporary benchmarks (TBM) were established at the stream gage location to provide differential vertical datum checks for the gage equipment to monitor movement. The Grant Creek stream gage for the 2013 season is tied into an elevation established arbitrary datum based on local TBMs.

Data loggers were operated during ice free months (i.e., April-October). The stream gage was visited every 6-8 weeks through late-September. The field team download data from the data loggers and took a discharge measurement to build and calibrate the rating curve. Additional discharge measurements were taken by the instream flow team when wading conditions were safe. During winter site maintenance station visits, activities will include battery change-outs and staff gage recordings. This supplemental data documenting the winter period will be distributed to stakeholders and included in the Water Resources portion of Exhibit E in the LA.

Instantaneous Discharge Measurements

Collecting instantaneous discharge data from Grant Creek required two methods depending upon flow conditions. It is not possible to wade Grant Creek during flow events above 400 cfs. Potential instantaneous discharge measurement methods included the following:

- Wading method (low to medium-flow events on Grant Creek).
- Acoustic Doppler Current Profiler (ADCP) method (medium to high-flow events on Grant Creek).

All instantaneous discharge measurements yielded comparable results and followed field procedures laid out in Rantz et al (1982). The stream gage site was visited at least monthly, and instantaneous discharge measurements were taken until freeze-up as stream conditions permitted, to establish and calibrate the rating curve.

Wading Method – Instantaneous discharge measurements were taken using a top-setting wading rod with a Swoffer current meter.

Procedures for taking discharge measurements using a current meter in ice-free conditions are outlined below.

1. Visually check wading rod and current meter for damage. Repair damage to equipment and replace batteries as necessary.
2. Calibrate and test the current meter at the start of each field event according to manufacture protocols.
3. Anchor survey measuring tape tautly across the stream perpendicular to the direction of stream flow and attach it on either side of the stream with the low numbers of the tape on the left side of the stream. Calculate the width of the entire stream cross section.
4. Determine the spacing of the vertical partial sections (referred to as "verticals"). This is typically accomplished by splitting the entire stream cross section into approximately 25 to 35 verticals. The number of verticals will be based on an estimated distribution of the discharge across the entire cross section. Space the verticals to meet the USGS objective that no vertical partial section should contain more than 10 percent of the total discharge. The ideal measurement is one in which no partial section contains more than 5 percent of the total discharge. However, the placement of verticals should never be closer than a horizontal distance of 0.20 feet.
5. The person wading in the stream will call out the location of the first vertical with respect to the surveyor's tape to the person on shore who is recording data (data recorder). The station or vertical location is recorded to the nearest 0.1 feet.
6. Using the wading rod, the person wading in the stream will measure water depth at that vertical to the nearest 0.05 foot. The wading person will call out this depth reading to the data recorder and adjust the height of the current meter on the top-set wading rod according to the depth at that vertical. For water columns less than or equal to 2.5 feet deep, a single velocity measurement at 60 percent of the water column height will be collected. If the water is more than 2.5 feet deep, measurements should be made at 20 and 80 percent of the water-column height.
7. The person wading will stand downstream of the survey measuring tape, facing upstream and holding the wading rod vertical in the water with the current meter facing directly into the current. The wading person should stand to the side, rather than directly behind the meter, to avoid influencing velocity readings. Occasionally flow at a vertical may not be perpendicular to the tape due to a rock upstream or other flow restrictions. If the obstruction cannot be cleared and the flow is more than 20 degrees off perpendicular, the person in the stream should orient the meter directly into the flow and call out the angle

of flow with respect to perpendicular. A correction will be applied to the velocity measurement from the vertical when calculating the discharge.

8. The person wading will observe visual output of velocity measurements at each vertical. Velocity measurements averaged over a 40 second period before being recorded. The person recording data will record this and other appropriate information on the field form.
9. Repeat above procedure at each vertical.

ADCP Method - During higher flows when wading was not a safe option due to deep and fast-water conditions, the ADCP method was employed to obtain discharge measurements. An ADCP determines the velocity of water by sending sound pulses into the water column and measuring the change in frequency of the sound pulses. When this change in frequency (i.e. Doppler Shift) is reflected back to the ADCP transducer, it can be translated into water velocity. The ADCP also has an acoustic component within the transducer to measure water depth and horizontal distance. The ADCP sends sound pulses to the bottom of the stream channel and measures the travel time for each sound pulse to return to the ADCP. By mounting the ADCP to a small watercraft, it can be ferried across the channel to measure channel width, depth, and velocity verticals. Once the ADCP has effectively completed these measurements, discharge can be calculated using the conventional velocity-area method.

5 RESULTS

5.1. Water Quality and Temperature

Water Quality

Baseline water quality sampling for this Project was conducted during multiple years. Historical water quality data was collected by various entities and summarized for earlier Project scoping efforts (Ebasco 1984). Limited sampling was conducted in 2009 and 2010 and expanded sampling was conducted in 2013 to supplement and expand the previous sampling efforts. All 2013 sample results were compared to standards presented in the Alaska Department of Environmental Conservation's 18 AAC 70 Water Quality Standards Publication – Amended April 8, 2012 to establish whether standards were being met.

Sampling efforts in 2013 were conducted during three trips including June, August and September. A total of twenty-four parameters were monitored during the sampling period. Ten of the parameters monitored have established water quality standards (see Table 4.1-1).

Trail Lakes Narrows

Three sampling events were conducted at this site (June, August, and September 2013). Table 5.1-1 provides the results of 2013 sampling for this site. No parameter sampled exceeded water quality standards during any sampling event. Specific parameters of aquatic interest (dissolved oxygen, pH and temperature) met standards for all sampling periods. Compared to the Grant Lake and Grant Creek sites, Trail Lakes Narrows routinely had the highest turbidity readings of all sites in 2013. This site was also the only site sampled for diesel and gas components, both of

which were below detection levels for all three sample events. Some minor variability was noted between *in situ* and laboratory pH values at the TLN site. This discrepancy is most likely due to the pH field probe accuracy, which tends to be less reliable than lab measurements.

Table 5.1-1. Water quality sampling results for the Trail Lake Narrows (TLN) site – 2013. [1,2]

Hydrolab Readings		Hydrolab #1 June 2013	Hydrolab #2 June 2013	Hydrolab #1 August 2013	Hydrolab #2 August 2013	Hydrolab #1 Sept 2013	Hydrolab #2 Sept 2013
Temp	**°C**	9.05	9.08	11.81	11.94	8.39	8.51
Sp. Cond	**mS/cm**	0.08	0.08	0.07	0.04	0.07	0.07
Dissolved Oxygen	**% Sat**	102.5	102.5	102.9	102.1	87.4**	102.6
Dissolved Oxygen	**mg/l**	11.88	11.85	11.19	11.09	10.8**	11.82
ORP	**mV**	399	385	526	315	387	335
pH	**S.U.**	7.51	7.63	7.63	6.32	7.06	6.60
Turbidity	**NTU**	9.4	*	*	*	9.4	*
Depth	**m**	1.6	1.7	2.0	2.0	1.0	1.0
Analytical Lab Results			DUP				DUP
pH	**S.U.**	7.60	7.60	6.90		7.20	7.10
Turbidity	**NTU**	8.5	8.8	13.0		11.0	11.0
T. Hardness	**mg/l**	38.9	41.2	33.0		36.8	33.8
T. Alkalinty	**mg/l**	25.1	25.5	18.7		22.0	21.8
TDS	**mg/l**	44	49	43		54	50
TSS	**mg/l**	3.1	5.7	11.3		4.1	3.8
T. Nitrate+Nitrite	**mg/l**	0.35	0.39	0.14		0.27	0.25
K. Nitrogen	**mg/l**	ND	ND	ND		ND	ND
T. Phosphorus	**mg/l**	ND	ND	0.03		ND	0.01
Orthophosphate	**mg/l**	ND	ND	0.02		0.02	0.02
Chloride	**mg/l**	0.32	0.32	0.21		0.21	0.21
Fluoride	**mg/l**	ND	ND	ND		ND	ND
Sodium	**mg/l**	1.17	1.15	0.91		0.99	1.05
Calcium	**mg/l**	13.6	14.4	11.3		12.5	11.4
Magnesium	**mg/l**	1.2	1.3	1.2		1.4	1.3
Potassium	**mg/l**	0.53	0.59	ND		0.62	0.56
Sulfate	**mg/l**	16.0	16.0	13.1		15.0	15.0
Lead	**µg/l**	0.2	ND	0.40		0.30	0.23
Low level Mercury	**µg/l**	0.0017	0.0016	0.0036		0.0022	0.0022
Gas Range Organics	**mg/l**	ND	ND	ND		ND	ND
Diesel Range Organics	**mg/l**	ND	ND	ND		ND	ND

Notes
ND: not detected
1. Probe manufacturer confirmed LDO sensor was malfunctioning – Hydrolab #1 values not accurate
2. Faulty turbidity probe

Grant Creek

There were three sampling sites on Grant Creek, all located below the canyon reach. Each site was sampled once in August 2013. The 2013 results indicated all parameter levels were below ADEC standards. Little variability between these creek sites was observed in 2013. Turbidity

values ranged from 4.0-4.6 NTUs, dissolved oxygen ranged from 10.95-11.02 mg/l, and pH values from 7.00-7.18 S.U.

Three sites initially established in 2009 were sampled again in 2010 and 2013. Results from the three years of sampling are presented in Tables 5.1-2 through 5.1-4. No parameter sampled exceeded water quality standards during the three sampling events. Grant Creek results showed little variation between years for most parameters. Differences in sampling results for dissolved oxygen between 2009/2010 and 2013 may be a result of equipment calibration or faulty sensor issues with the equipment used in 2009-2010. The 2013 sampling used duplicate multi-probe *in situ* instruments in an attempt to alleviate this problem and insure accurate results.

Table 5.1-2. Water quality sampling results for the Grant Creek GC100 site – 2009, 2010, and 2013. [1,2]

Hydrolab Readings		Jun-09	Aug-09	Jun-10	Aug-13
Temp	**°C**	9.44	12.32	8.55	12.65
Sp. Cond	**mS/cm**	0.08	0.09	0.09	0.06
Dissolved Oxygen	**% Sat**	68.7	77.5	91.9	102.5
Dissolved Oxygen	**mg/l**	7.85	8.29	10.74	10.95
ORP	**mV**	na	na	212	422
pH	**S.U.**	7.39	7.4	7.23	7.18
Turbidity	**NTU**	0.77	10.10	1.14	4.10
Depth	**m**	na	na	na	1.9
Lab Analyses					
pH	**S.U.**	na	na	na	7.00
Turbidity	**NTU**	na	na	na	4.1
T. Alkalinity	**mg/l**	24	23	25	20.4
T. Hardness	**mg/l**	na	na	na	34.2
TDS	**mg/l**	53.8	62.5	52.0	45.0
TSS	**mg/l**	0.70	2.49	0.71	1.78
T. Nitrate/Nitrite	**mg/l**	0.46	0.30	0.27	0.18
K. Nitrogen	**mg/l**	ND	ND	ND	ND
Orthophosphate	**mg/l**	ND	ND	ND	ND
T. Phosphorus	**mg/l**	ND	ND	0.022	ND
Chloride	**mg/l**	na	na	0.293	0.225
Fluoride	**mg/l**	na	na	ND	ND
Sodium	**mg/l**	na	na	1.10	0.98
Calcium	**mg/l**	na	na	12.6	11.6
Magnesium	**mg/l**	na	na	1.28	1.24
Potassium	**mg/l**	na	na	0.52	0.53
Sulfate	**mg/l**	na	na	18.0	15.5
Lead	**µg/l**	0.597	ND	0.597	ND
LL Mercury	**µg/l**	ND	0.0015	ND	0.0015

Notes
1 na: not sampled
2 ND: not detected

Table 5.1-3. Water quality sampling results for the Grant Creek GC200 site – 2009, 2010, and 2013. [1,2]

Hydrolab Readings		Jun-09	Aug-09	Jun-10	Aug-13
Temp	°C	7.4	11.26	8.51	12.46
Sp. Cond	mS/cm	na	0.07	0.09	0.06
Dissolved Oxygen	% Sat	60.9	75.1	92.3	101.5
Dissolved Oxygen	mg/l	7.31	8.22	10.79	10.89
ORP	mV	na	na	216	408
pH	S.U.	7.66	7.39	7.39	7.02
Turbidity	NTU	0.75	11.10	1.17	4.00
Depth	m	na	na	na	1.9
Lab Analyses					
pH	S.U.	na	na	na	7.00
Turbidity	NTU	na	na	na	4.0
T. Alkalinity	mg/l	25.0	23.5	25.5	20.6
T. Hardness	mg/l	na	na	na	34.4
TDS	mg/l	60	44	50	51
TSS	mg/l	0.8	3.4	0.7	2.9
T. Nitrate/Nitrite	mg/l	0.455	0.292	0.269	0.190
K. Nitrogen	mg/l	ND	ND	ND	ND
Orthophosphate	mg/l	ND	ND	ND	ND
T. Phosphorus	mg/l	ND	ND	ND	ND
Chloride	mg/l	na	na	0.284	0.225
Fluoride	mg/l	na	na	ND	ND
Sodium	mg/l	na	na	1.14	1.18
Calcium	mg/l	na	na	13.3	11.7
Magnesium	mg/l	na	na	1.26	1.25
Potassium	mg/l	na	na	0.52	0.54
Sulfate	mg/l	na	na	17.9	15.1
Lead	µg/l	3.09	ND	ND	ND
LL Mercury	µg/l	ND	0.0016	ND	0.0013

Notes
1 na: not sampled
2 ND: not detected

Table 5.1-4. Water quality sampling results for the Grant Creek GC300 site – 2009, 2010, and 2013.

Hydrolab Readings		Jun-09	Aug-09	Jun-10	Aug-13
Temp	°C	7.47	11.49	8.53	12.45
Sp. Cond	mS/cm	0.09	0.09	0.09	0.06
Dissolved Oxygen	% Sat	61.3	77.1	93.7	102.8
Dissolved Oxygen	mg/l	7.34	8.40	10.94	11.02
ORP	mV	na	na	209	421
pH	S.U.	7.30	7.72	7.52	7.09
Turbidity	NTU	0.8	11.9	1.0	4.6
Depth	m	na	na	na	1.8
Lab Analyses					
pH	S.U.	na	na	na	7.00
Turbidity	NTU	na	na	na	4.6
T. Alkalinity	mg/l	25.0	23.0	25.3	20.7
T. Hardness	mg/l	na	na	na	34.9
TDS	mg/l	57.5	60.0	54.0	45.0
TSS	mg/l	0.8	2.9	0.7	3.1
T. Nitrate/Nitrite	mg/l	0.42	0.32	0.36	0.18
K. Nitrogen	mg/l	ND	ND	ND	ND
Orthophosphate	mg/l	na	na	ND	ND
T. Phosphorus	mg/l	0.023	ND	ND	ND
Chloride	mg/l	na	na	0.29	0.22
Fluoride	mg/l	na	na	ND	ND
Sodium	mg/l	na	na	1.1	1.0
Calcium	mg/l	na	na	13.0	11.9
Magnesium	mg/l	na	na	1.3	1.3
Potassium	mg/l	na	na	0.5	0.5
Sulfate	mg/l	na	na	17.9	15.3
Lead	µg/l	0.392	ND	ND	ND
LL Mercury	µg/l	na	0.0020	ND	0.0018

Notes
1 na: not sampled
2 ND: not detected

Grant Lake

The 2013 sampling was repeated at the two original sites (HDR 2009, 2010). Results from the three years of sampling are presented in Tables 5.1-5 and 5.1-6. There were two distinct sampling sites, site GLTS representing typical lake conditions of the lower basin and site GLOut representing outflow conditions into Grant Creek. The GLTS site was located in the immediate vicinity of the proposed intake structure location. Both sites were sampled in August 2013. Each site was sampled vertically at selected depths for grab analyses and at one meter depth intervals for *in situ* parameters. No parameter sampled exceeded water quality standards during the August sampling event.

In situ sampling during 2013 at the GLTS site was done from the surface down to a bottom depth of 17 meters. Dissolved oxygen ranged from 103.6 percent saturation at the surface to 94.5percent saturation at the bottom. A mid-depth (8.0 meters) reading was 100.9 percent saturation. Dissolved oxygen concentrations for these same depths ranged from a surface reading of 11.15 mg/l, increasing to 11.76 mg/l at the bottom. A mid-depth concentration was 11.18 mg/l. The pH levels ranged from 7.26 S.U. at the surface to 7.42 S.U. at the bottom. Instantaneous temperature readings ranged from 12.3 °C at the surface to 6.24 °C at the bottom. A mid-depth temperature was 10.98 °C.

In situ sampling during 2013 at the GLOut site was done from the surface down to a mid-depth of 5 meters. Dissolved oxygen ranged from 103.3 percent saturation at the surface to 98.0 percent saturation at the mid depth. Dissolved oxygen concentrations for these same depths ranged from a surface reading of 11.14 mg/l to 10.69 mg/l at the mid depth. The pH levels ranged from 6.33 S.U. at the surface to 6.79 S.U. at the mid-depth. The instantaneous temperature readings ranged from 12.2 °C at the surface to 11.6 °C at the mid-depth.

Data for the two lakes sites was initially collected in 2009 and repeated in June of 2010. Results appear similar for nearly all parameters where three years of data exists. Differences in sampling results for dissolved oxygen between 2009/2010 and 2013 may be a result of poor equipment calibration or faulty sensor issues with the equipment used in 2009/2010. The 2013 sampling used duplicate multi-probe instruments in an attempt to alleviate this problem and insure accurate results.

Differences at sites GLout and GLTS in dissolved oxygen and pH values were also noted between the 2013 results and the 2009-2010 results. It is unclear whether this is a result of fluctuating annual conditions or faulty sampling equipment as noted earlier. However, Grant Lake water quality data summarized by Ebasco (1984) indicate that the 2013 results are more in line with historical results.

Table 5.1-5. Water quality sampling results for the Grant Lake GLOut site – 2009, 2010, and 2013. [1,2]

Hydrolab Readings		Jun-09	Jun-09	Aug-09	Aug-09	Jun-10	Jun-10	Aug-13	Aug-13
Depth	**m**	0-Surf	4-Mid	0-Surf	6-Mid	0-Surf	6-Mid	0-Surf	3-Mid
Temp	**°C**	7.95	7.27	14.87	11.49	9.38	9.30	12.17	11.81
Sp. Cond	**mS/cm**	na	na	0.09	0.09	0.08	0.08	0.08	0.08
Dissolved Oxygen	**% Sat**	64.4	63.8	55.2	52.3	75.5	74.0	103.3	101.9
Dissolved Oxygen	**mg/l**	7.64	7.70	5.57	5.71	8.61	8.50	11.14	11.08
ORP	**mV**	na	na	na	na	73	29	334	332
pH	**S.U.**	7.27	7.37	7.24	7.24	6.98	7.06	6.28	6.59
Turbidity	**NTU**	0.82	na	4.18	na	1.46	1.14	4.50	5.10
Lab Analyses									
pH	**S.U.**	na	na	na	na	na	na	7.10	7.00
Turbidity	**NTU**	na	na	na	na	na	na	4.5	5.1
T. Alkalinity	**mg/l**	23.8	23.2	24.0	24.0	26.0	25.6	20.8	20.9
T. Hardness	**mg/l**	na	na	na	na	na	na	35.6	36.5
TDS	**mg/l**	51.3	40.0	32.5	47.5	57.0	64.0	46.0	52.0
TSS	**mg/l**	0.60	0.50	1.96	2.77	ND	0.75	2.08	2.75
T. Nitrate/Nitrite	**mg/l**	0.414	0.651	0.268	0.298	0.311	0.344	0.206	0.175
K. Nitrogen	**mg/l**	ND	ND	ND	ND	ND	ND	ND	ND
Orthophosphate	**mg/l**	ND	ND	ND	ND	ND	ND	ND	ND
T. Phosphorus	**mg/l**	ND	ND	ND	ND	ND	ND	ND	ND
Chloride	**mg/l**	na	na	na	na	0.298	0.291	0.221	0.220
Fluoride	**mg/l**	na	na	na	na	ND	ND	ND	ND
Sodium	**µg/l**	na	na	na	na	1.16	1.12	0.95	0.95
Calcium	**µg/l**	na	na	na	na	13.8	13.4	11.5	11.6
Magnesium	**µg/l**	na	na	na	na	1.32	1.27	1.18	1.2
Potassium	**µg/l**	na	na	na	na	0.53	0.53	0.51	0.51
Sulfate	**mg/l**	na	na	na	na	17.6	17.9	15.3	15.4
Lead	**µg/l**	ND	ND	ND	ND	ND	ND	0.24	ND
LL Mercury	**µg/l**	ND	ND	0.0014	0.0021	0.0011	0.0011	0.0011	0.0014

Notes
1 na: not sampled.
2 ND: not detected.

Table 5.1-6. Water quality sampling results for the Grant Lake GLTS site – 2009, 2010, and 2013. [1,2]

Hydrolab Readings		Jun-09	Jun-09	Jun-09	Aug-09	Aug-09	Aug-09	Jun-10	Jun-10	Jun-10	Aug-13	Aug-13	Aug-13
Depth	**m**	0-Surf	10-Mid	19-Bot	0-Surf	9-Mid	17-Bot	0-Surf	6-Mid	17-Bot	0-Surf	9-Mid	17 - Bot
Temp	**°C**	8.64	5.41	4.33	14.66	10.37	6.09	9.36	9.25	4.41	12.29	10.98	6.24
Sp. Cond	**mS/cm**	0.09	0.09	0.09	0.09	0.09	0.1	na	na	na	0.08	0.08	0.09
Dissolved Oxygen	**% Sat**	68.4	61.3	55.5	56.2	52.1	48.4	76.2	74.1	66.5	103.6	100.9	94.5
Dissolved Oxygen	**mg/l**	7.96	7.74	7.2	5.63	5.82	5.99	8.73	8.52	8.63	11.15	11.18	11.76
ORP	**mV**	na	na	na	na	na	na	91	26	65	319	320	327
pH	**S.U.**	7.43	7.49	7.06	7.56	7.2	7.06	6.68	6.82	6.43	7.26	7.42	7.42
Turbidity	**NTU**	0.6	na	na	3.87	na	4.8	0.81	1.14	1.17	3.9	7.8	4.8
Lab Analyses													
pH	**S.U.**	na	na	na	na	na	na	na	na	na	6.80	6.80	6.80
Turbidity	**NTU**	na	na	na	na	na	na	na	na	na	3.9	7.8	4.8
T. Alkalinity	**mg/l**	23.5	24.5	24	24.8	24.6	25.4	25.8	25.3	25.8	20.2	20.9	22.6
T. Hardness	**mg/l**	na	na	na	na	na	na	na	na	na	36.1	36.9	39.7
TDS	**mg/l**	75.0	68.8	61.3	46.3	48.8	45.0	67.0	64.0	63.0	43.0	45.0	49.0
TSS	**mg/l**	0.7	1.0	0.8	1.9	2.6	2.8	0.5	ND	0.7	2.7	2.6	4.2
T. Nitrate/Nitrite	**mg/l**	0.42	0.42	0.41	0.28	0.30	0.32	0.30	0.31	0.30	0.17	0.19	0.31
K. Nitrogen	**mg/l**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Orthophosphate	**mg/l**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.01	ND
T. Phosphorus	**mg/l**	ND	0.021	ND	ND	ND	ND	ND	ND	ND	ND	0.02	0.04
Chloride	**mg/l**	na	na	na	na	na	na	0.30	0.29	0.47	0.22	0.22	0.27
Fluoride	**mg/l**	na	na	na	na	na	na	ND	ND	ND	ND	ND	ND
Sodium	**mg/l**	na	na	na	na	na	na	1.16	1.15	1.16	0.95	0.96	1.08
Calcium	**mg/l**	na	na	na	na	na	na	13.5	13.3	13.4	11.6	11.6	13.0
Magnesium	**mg/l**	na	na	na	na	na	na	1.3	1.3	1.3	1.2	1.2	1.3
Potassium	**mg/l**	na	na	na	na	na	na	0.53	0.51	0.52	0.51	0.53	0.52
Sulfate	**mg/l**	na	na	na	na	na	na	18.0	17.9	17.9	15.1	15.4	16.9
Lead	**µg/l**	ND	1.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LL Mercury	**µg/l**	ND	ND	ND	0.0015	0.0016	0.0017	ND	ND	ND	0.0011	0.0015	0.0015

Notes
1 na: not sampled
2 ND: not detected

Temperature

2013 Results

A total of nine temperature sites were monitored in 2013 including six main channel Grant Creek sites, two off-channel Grant Creek sites and one Grant Lake site. All of these sites provide water temperature data for the 2013 season. Appendices 1a and 1b summarize the 2013 temperature record at all of the sampling locations.

Grant Creek

Six sites were monitored in 2013 on Grant Creek. They included four previously established sites (GC100, GC200. GC250, GC300), two new upstream sites (GC500 and GC600) in the canyon reach and two off channel sites (ISF 230 and ISF 300) selected based on observed fish utilization.

Daily mean temperature hydrographs for the six main channel Grant Creek sites are presented in Figure 5.1-1. Mean daily temperatures at all sites track are very similar to one another with the exception of GC600 in early to mid April. GC600 is located less than 100 feet from the outlet of Grant Lake and may be less affected by changes in air temperature when outlet flows are low and Grant Lake is still under ice cover.

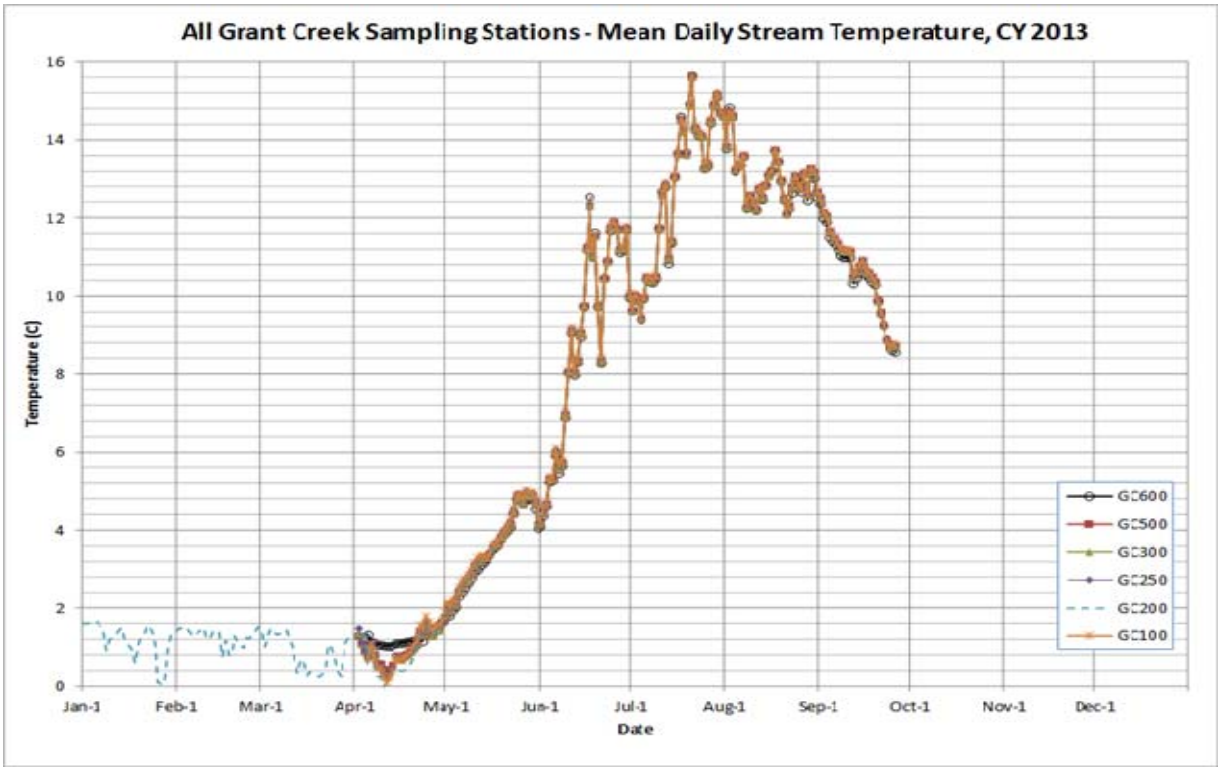


Figure 5.1-1. Daily mean water temperatures all Grant Creek main channel sites – 2013.

Winter temperature data was collected at one site (GC200). The January-April 2013 record indicates that the minimum daily mean water temperature for this period was 0.0 ° C and the maximum daily mean water temperature for this period was 1.8 ° C. The daily mean average temperature for January was 1.2 °C; for February it was 1.3 °C; and for March and April it was 0.9 °C. Following the month of April, mean daily temperature values increase through the month of August (mean monthly average of 12.1 °C), before decreasing once again in September (mean monthly average of 8.6 °C).

Grant Creek water temperatures demonstrate little inter-station variations in 2013 throughout longitudinal profile of Grant Creek. Figure 5.1-2 shows a comparison of daily mean water temperatures between the farthest upstream site (G600) and the farthest downstream site (G100). As stated earlier GC600 temperatures may be buffered from extreme late winter air temperatures due to its proximity of releases from the ice covered lake.

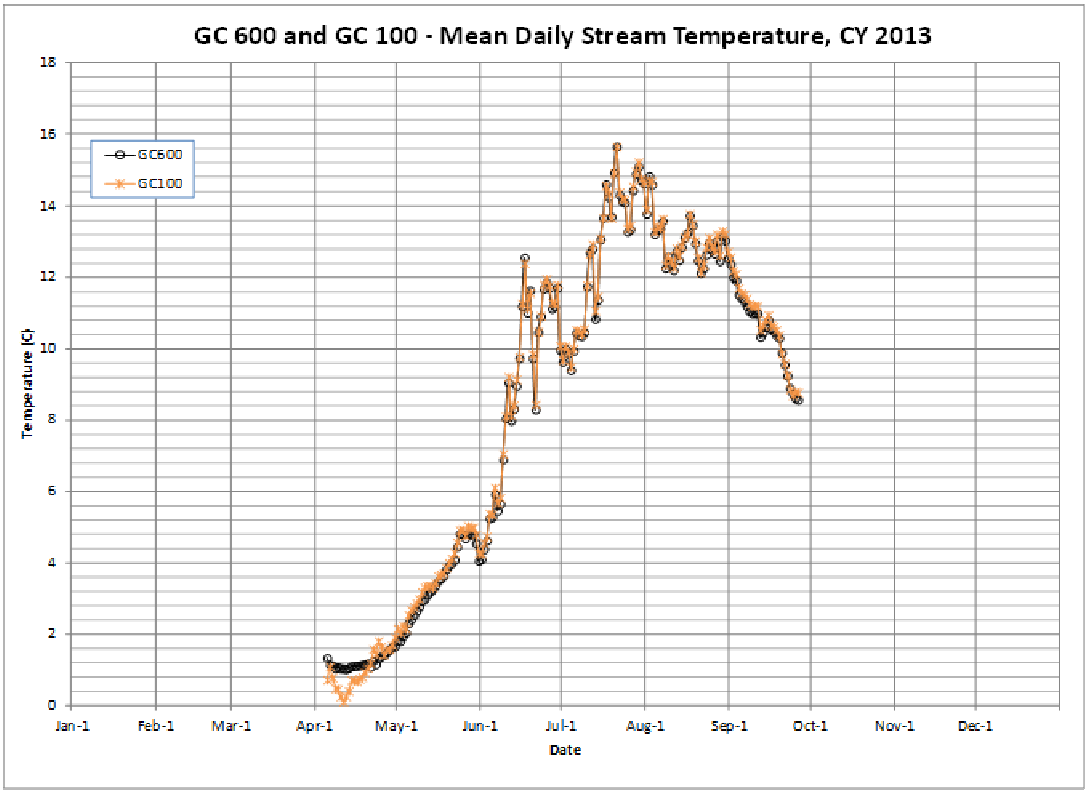


Figure 5.1-2. Comparison of daily mean water temperatures upstream and downstream Grant Creek sample stations – 2013.

Additional stream temperature data was collected at two off site channel locations. These backwater areas were selected in coordination with members of the Aquatic Resources study team that detected juvenile salmonids (resident and anadromous) rearing at these two locations. Figure 5.1-3 shows the results of daily mean temperatures at both off channel sites (GC 200-oc and GC 250-oc) from June through late September 2013 in comparison to main channel temperatures. Site GC 200-oc temperatures remained cooler and more stable when compared to

temperatures recorded at GC 250-oc. The cooler temperatures at GC 200-oc are likely due to different physical characteristics of site (greater depth, denser canopy cover, and more isolation from main channel flows) as well as more groundwater influence. In general, both off channel sites were slightly cooler when compared to main channel temperatures. Although GC 250-OC was slightly cooler than main channel temperatures, the inter-daily temperature fluctuations still appeared to follow patterns detected in the main channel. This may be due in part to potential groundwater influences at each site.

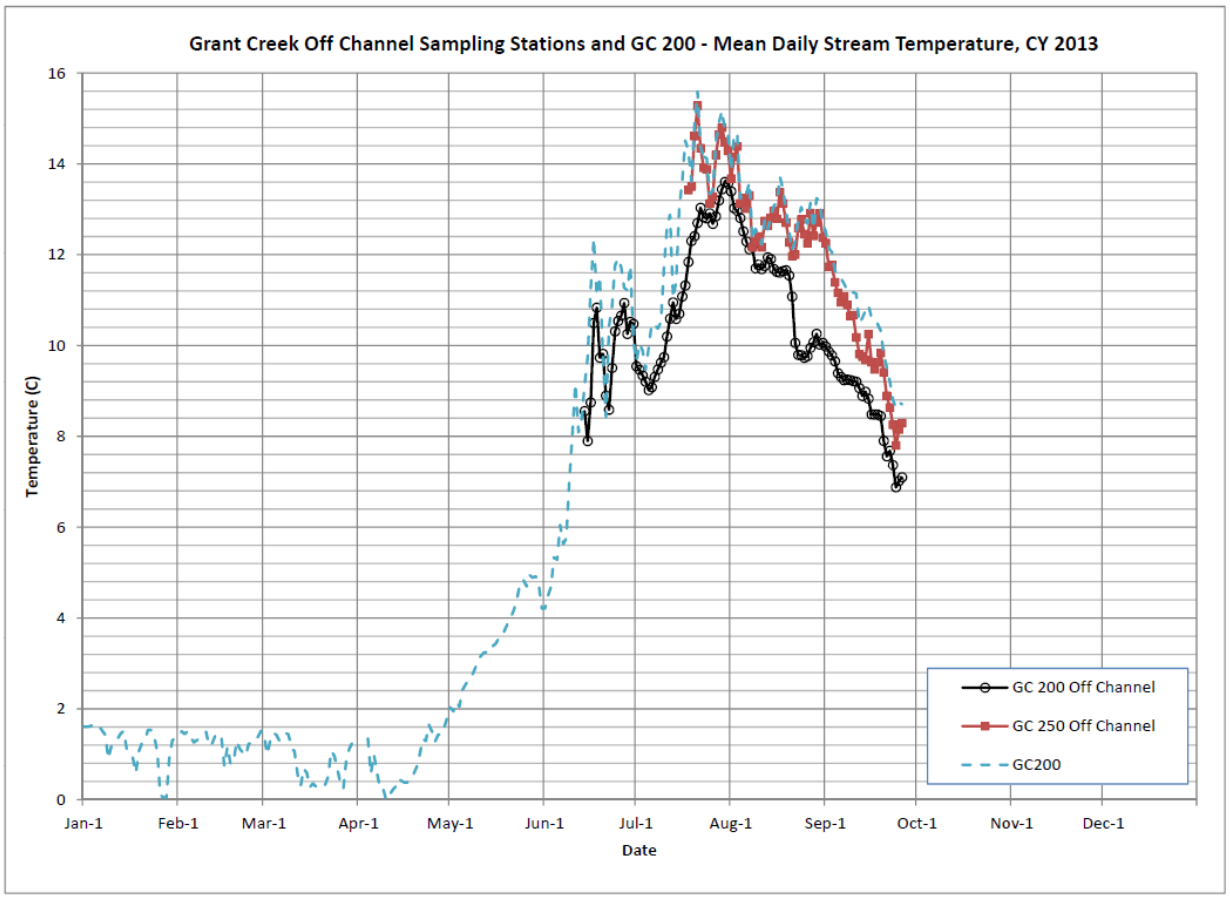


Figure 5.1-3. Comparison of daily mean water temperatures between two off channel rearing locations and the main channel of Grant Creek – 2013.

Grant Lake

The temperature monitoring site in Grant Lake (GLTS) from the 2009/2010 work was re-established in the same approximate location for 2013. This site was monitored using a vertical temperature string which recorded temperatures at ten distinct depth intervals from the surface to a bottom depth of 19.5 meters.

Grant Lake water temperature hydrographs are presented in Figure 5.1-4. The temperature monitoring results show two distinct seasonal characteristics within Grant Lake. The first characteristic is that winter water temperatures increased with depth. This trend was noted from January through mid to late May. The second trend is that summer water temperatures decreased with depth, starting in June and extending through early September. A maximum difference of about 10 °C between the surface (0.2 meter) and the deepest sampling node (19.5 meter) was recorded in late July through early August.

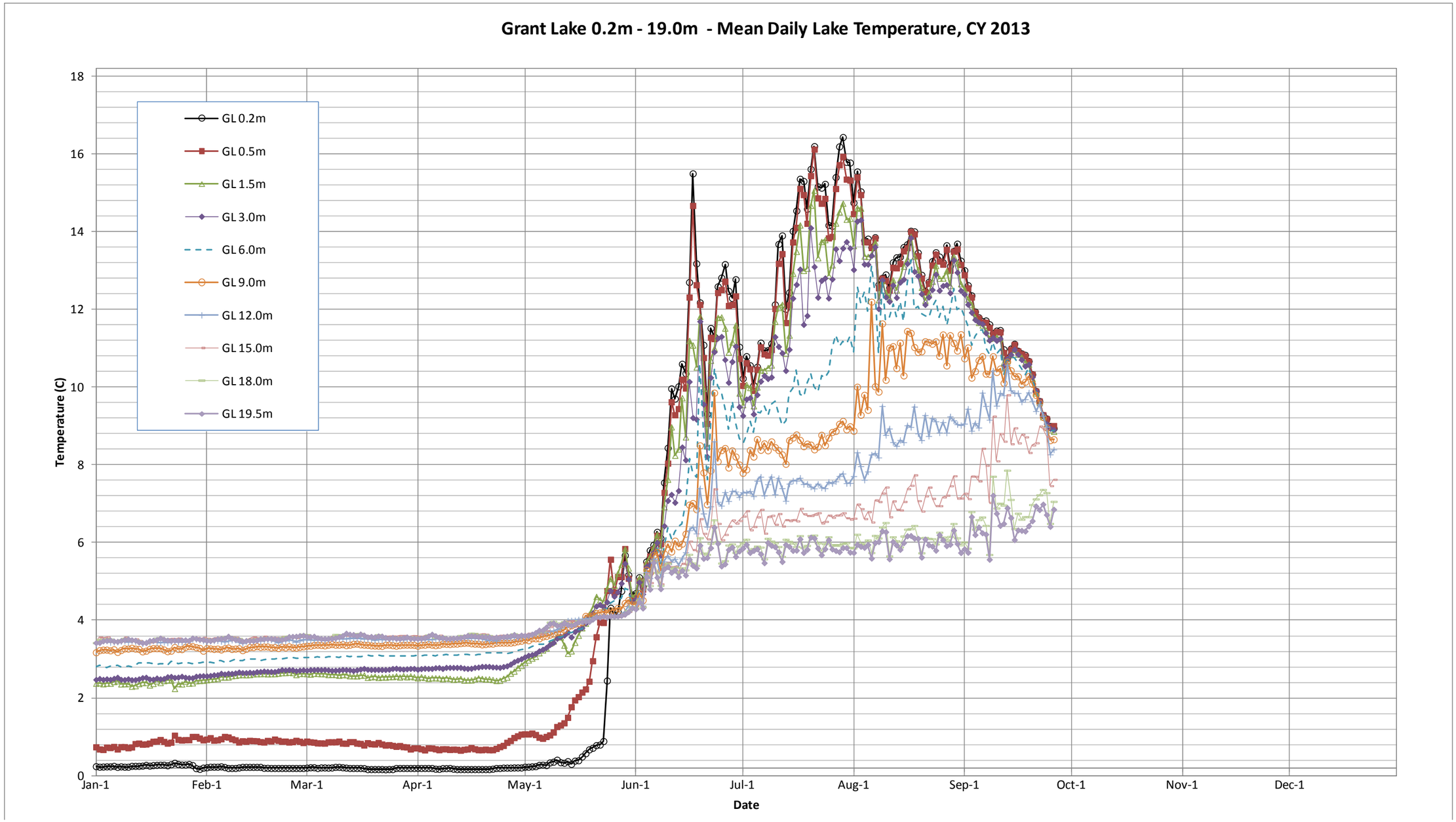


Figure 5.1-4. Comparison of daily mean water temperatures in Grant Lake near the proposed intake structure – 2013.

Figure 5.1-5 displays the seasonal temperature profile of Grant Lake in 2013. A noted temperature difference from top to bottom does exist throughout the year, but changes appear subtly during periods of ice cover and become more pronounced during the ice-free season. As confirmed in Figure 5.1-6, these temperature patterns have been consistent based on historical temperature profile results (AEIDC 1983; HDR 2009)

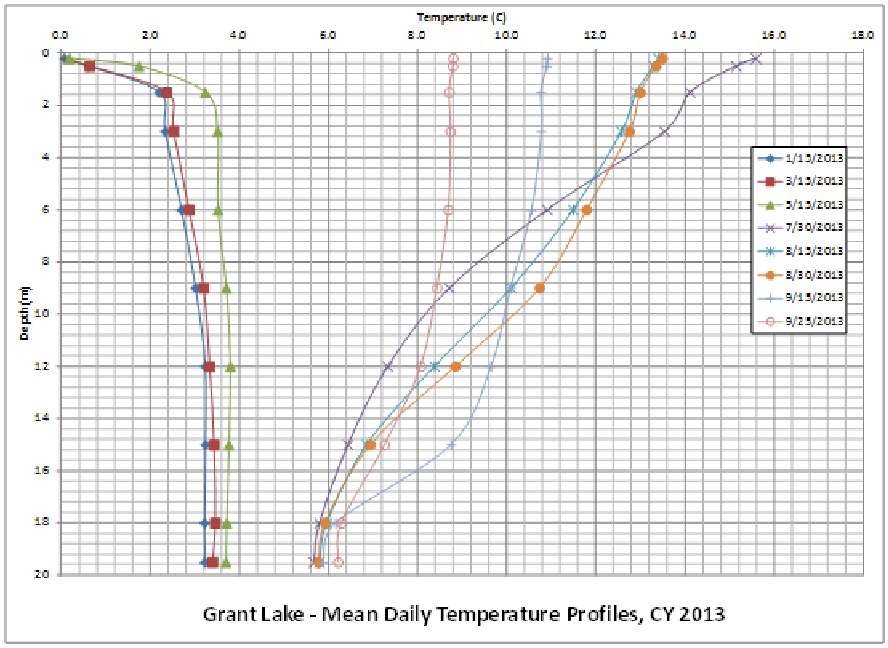
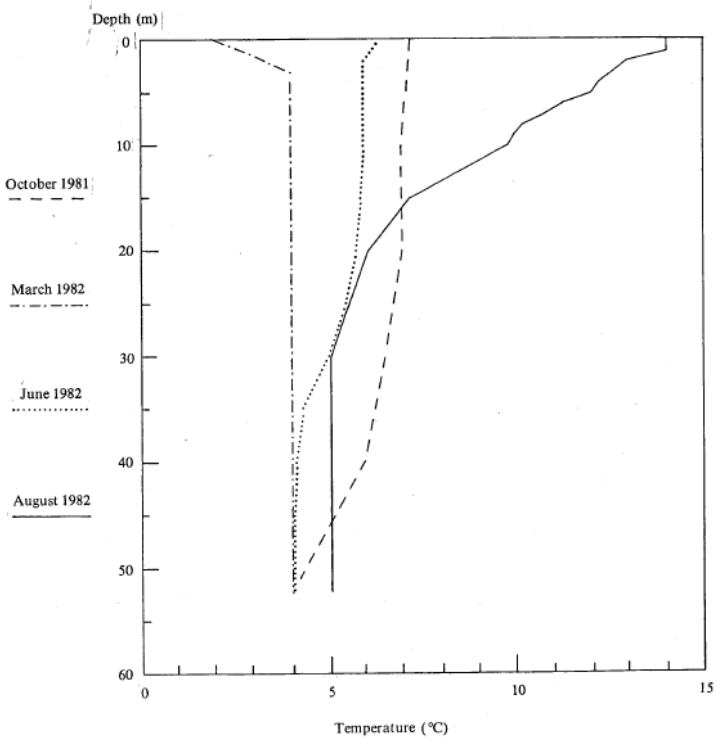
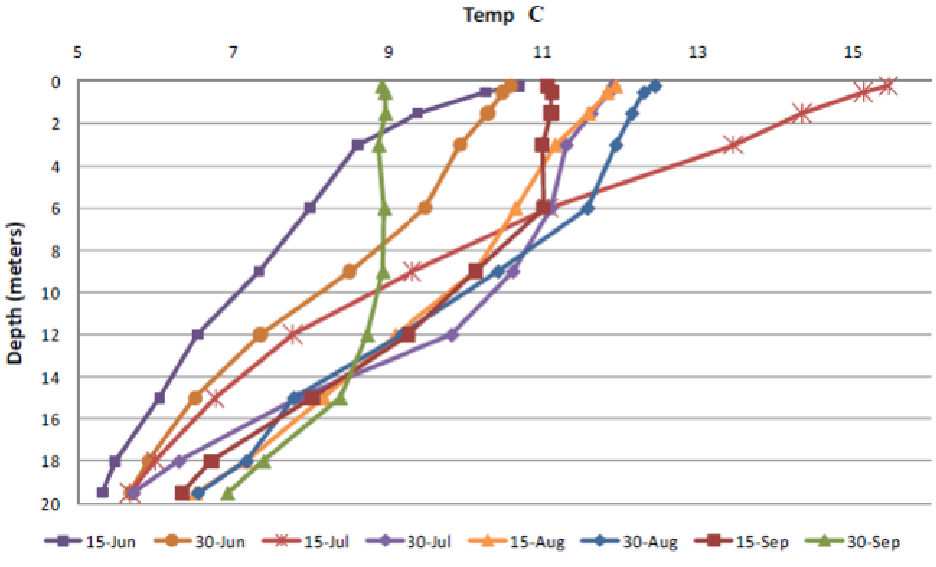


Figure 5.1-5. Daily mean water temperature profiles in Grant Lake near the proposed intake structure



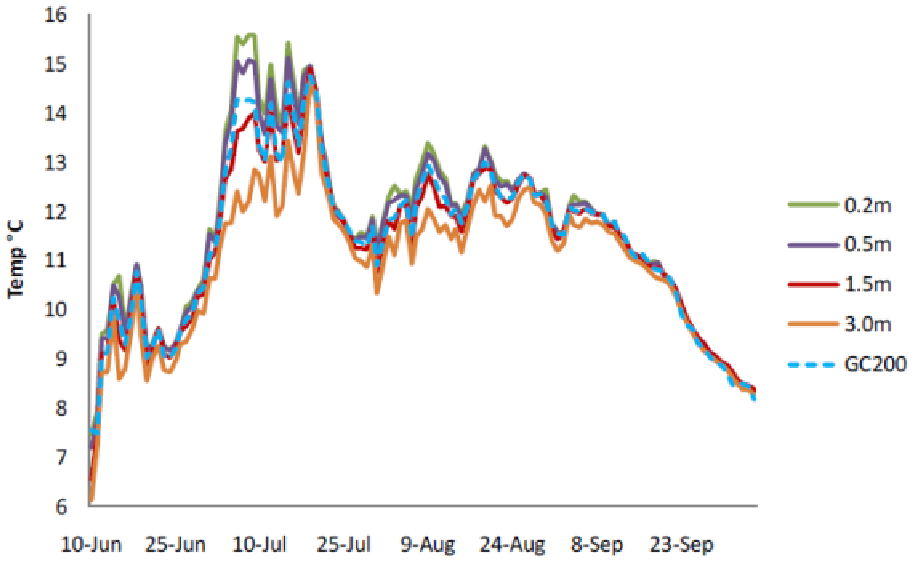
a)



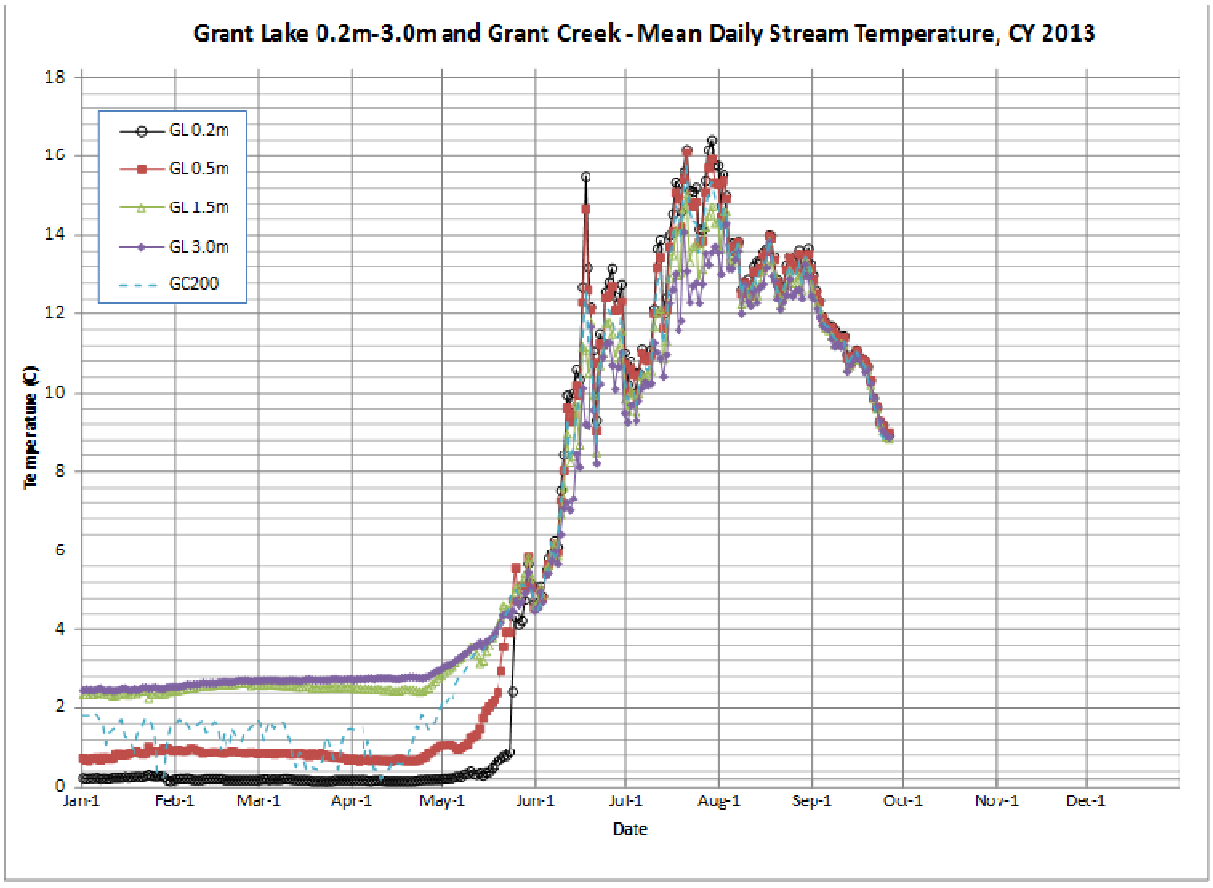
b)

Figure 5.1-6. Historical water temperature profiles in Grant Lake from a) AEIDC and b) HDR.

Temperature results from Grant Lake and Grant Creek indicate lake water temperatures closely mirror and influence creek water temperatures during periods when the lake is ice-free. The strongest correlation appears to be between creek temperatures and the upper surface lake depths (0.2 – 3.0 meters). Figure 5.1-7 shows a comparison of Grant Lake water temperatures from the four shallow sampling depths compared to Grant Creek (GC200) in 2009 and 2013.



a)



b)

Figure 5.1-7. A comparison of daily mean water temperatures for shallow depths (≤ 3m) of Grant Lake and Grant Creek in a) 2009 and b) 2013.

A further review of the data reveals that water temperatures in Grant Lake at a depth of 1.5 meters most closely match Grant Creek water temperatures during ice-free periods (Figure 5.1-8). For the May-September monitoring period, mean monthly temperatures at GLTS-1.5m and GC 200 are within 0.5 °C. In the 2013 winter period (January-April), mean monthly temperatures at GLTS-1.5m are up to 1.5 °C warmer than Grant Creek (GC200) temperatures. The trend of Grant Creek and GLTS-1.5m water temperatures nearly matching during the ice-free season is also confirmed by the 2009 temperature monitoring efforts (HDR 2009) and revealed in Figure 5.1-7.

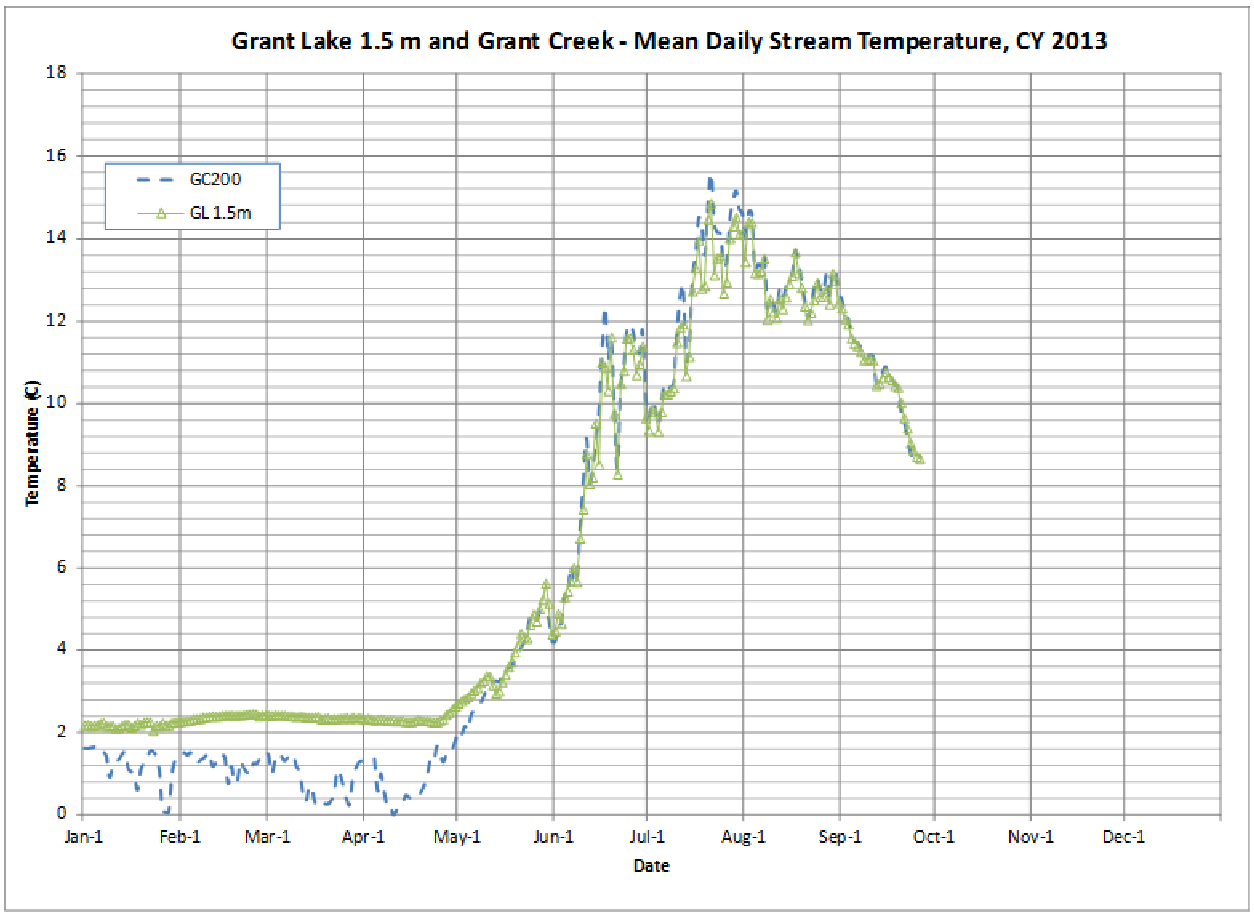


Figure 5.1-8. A comparison of daily mean water temperatures for Grant Lake at a depth of 1.5 meter and Grant Creek – 2013.

Instantaneous temperature profiles and continuous temperature monitoring in 1983 (AEIDC 1983) and 2009 (HDR 2009) have been summarized. Appendices 1c and 1d contain all of the available Grant Creek and Grant Lake temperature data since the 2009 study report was filed.

It should be noted that Grant Lake temperature data presented in this report for the years 2010 through the first half of 2013 were compiled from the thermistor string recovered on June 15, 2013. Although the thermistor string drifted slightly from the GLTS location, these data

represent a valid and comparable data set for describing vertical temperature changes in the lower basin of Grant Lake. Also, Grant Lake temperature data is available at all of the sampling depths from 2010-2013, but based on the gradual changes in water temperatures by depth, only surface (1.5 meters), middle (9.0 meters), and near bottom (18.0 meters) temperature records are provided.

There is very little inter-annual variation of temperatures near the surface of Grant Lake. The differences in the spring warming period are most likely linked to ice breakup while peak summer temperatures and declining fall temperatures are responding to ambient air conditions. Inter-annual variations within the mid-column and bottom of Grant Lake are less pronounced than at the surface. Peak temperatures at 9.0 meters were found in early August during the 2011 and 2013 seasons, while the 2012 maximum mean daily temperature occurred in early July. Near the bottom of the Grant Lake monitoring station, daily mean temperatures peak in early to mid September. Over the three year monitoring period, the 1.5 meters, 9.0 meters, and 18.0 meters stations had annual variations in maximum mean daily temperature values of 1.8 °C, 1.7 °C, and 1.3 °C respectively.

Grant Creek

Grant Creek water temperatures were monitored and summarized in 2009 (HDR 2009). A thermologger recovered at station GC250 in April 2013 provides continuous temperature data for the fall of 2009, all of 2010, and for the first days 37 days of 2011. Site GC 200, approximately 450 feet downstream of GC250, has temperature data for last 21 days of December 2012 through late September 2013.

The trend for Grant Creek temperatures, based on the data set, is to be at or below 2 °C during the winter months (December through late April). Water temperatures begin to rise sometime in late April or early May depending upon ice break up in Grant Lake. Water temperatures continue to rise throughout June and July before peaking sometime between mid-July to mid-August. Figure 5.1-9 summarizes all of the recent Grant Creek temperature records.

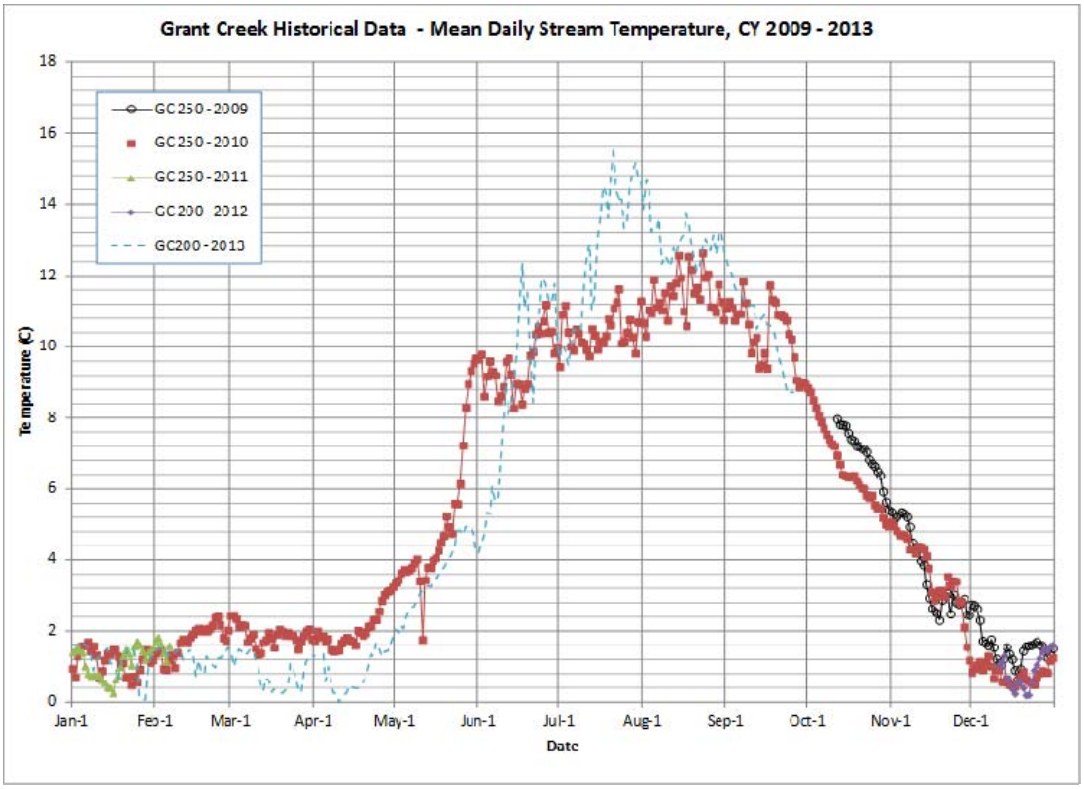


Figure 5.1-9. A comparison of daily mean water temperatures for Grant Creek, CY 2009 – 2013.

Data indicates that Grant Creek water temperatures, on average in 2010, were warmer (+0.5 °C) in the winter months and cooler (-3.5 °C) in the summer months when compared to 2013 results. Grant Creek water temperatures peaked in mid-August 2010 near 13 °C and in late July 2013 near 16 °C. The 2010 and 2013 datasets have limited overlapping data for the fall period. Although limited, the two years do show a similar late summer trends of slowly decreasing mean daily temperatures through mid-September before beginning a steady decline. The limited 2009 fall data also mirrors this same steady temperature decline though late November before freeze-up occurs.

5.2. Hydrology

2013 Stream Gaging

The GC 200 stream gage operated properly during the entirety of the April 2- September 27, 2013 monitoring period. A total of ten discharge measurements were taken to create and validate the stage-discharge relationship at Grant Creek and provide mean daily flow data from April 3 – September 27, 2013. The Grant Creek rating table is defined by two stage discharge equations. As seen in Table 5.2-1, Rating 1LF accurately predicts discharges for gage height values ranging from 0.30-0.99 feet, while Rating 1HF provides discharge values for stages ranging from 1.00-3.59 feet. The flow record for the 2013 season is considered to be of excellent reliability, with 10 discharge measurements validating the rating curve within 9.4 percent (Table 5.2-2). The

USGS criteria for and excellent stream flow record is that 95 percent of the discharge records are accurate within 10 percent. Mean daily flow statistics, discharge, and stage hydrographs are provided in Appendix 2a.

Table 5.2-1. Grant Creek ratings based on 2013 stage-discharge relationship at GC200.

DISCHARGE RATING # 1
GRANT CREEK NEAR MOOSE PASS, ALASKA

GAGE HEIGHT (FEET)	DISCHARGE IN CFS (Expanded precision)									
	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.30	9.49	10.04	10.6	11.2	11.8	12.4	13.0	13.6	14.2	14.9
0.40	15.5	16.2	16.9	17.6	18.3	19.0	19.7	20.5	21.2	22.0
0.50	22.7	23.5	24.3	25.1	25.9	26.8	27.6	28.4	29.3	30.1
0.60	31.0	31.9	32.8	33.7	34.6	35.5	36.4	37.4	38.3	39.3
0.70	40.3	41.2	42.2	43.2	44.2	45.2	46.3	47.3	48.3	49.4
0.80	50.5	51.5	52.6	53.7	54.8	55.9	57.0	58.1	59.3	60.4
0.90	61.5	62.7	63.9	65.0	66.2	67.4	68.6	69.8	71.0	72.3
1.00	74.8	76.4	78.0	79.7	81.3	83.0	84.7	86.4	88.1	89.8
1.10	91.6	93.4	95.1	97.0	98.8	101	102	104	106	108
1.20	110	112	114	116	118	120	122	124	126	128
1.30	130	133	135	137	139	141	144	146	148	150
1.40	153	155	157	160	162	164	167	169	172	174
1.50	177	179	182	184	187	189	192	195	197	200
1.60	203	205	208	211	213	216	219	222	225	227
1.70	230	233	236	239	242	245	248	251	254	257
1.80	260	263	266	269	272	275	278	282	285	288
1.90	291	294	298	301	304	308	311	314	318	321
2.00	325	328	331	335	338	342	345	349	353	356
2.10	360	363	367	371	374	378	382	386	389	393
2.20	397	401	405	408	412	416	420	424	428	432
2.30	436	440	444	448	452	456	460	464	469	473
2.40	477	481	485	490	494	498	502	507	511	515
2.50	520	524	529	533	538	542	547	551	556	560
2.60	565	569	574	579	583	588	593	597	602	607
2.70	612	616	621	626	631	636	641	645	650	655
2.80	660	665	670	675	680	685	691	696	701	706
2.90	711	716	721	727	732	737	742	748	753	758
3.00	764	769	775	780	785	791	796	802	807	813
3.10	818	824	830	835	841	846	852	858	864	869
3.20	875	881	887	892	898	904	910	916	922	928
3.30	934	940	946	952	958	964	970	976	982	988
3.40	994	1001	1007	1013	1019	1025	1032	1038	1044	1051
3.50	1057	1063	1070	1076	1083	1089	1096	1102	1109	1115

Q = 74.74453*(GH-0.01)^1.66750 for outside gage values 0.33 - 0.99
Q = 76.40686*(GH-0.01)^2.10189 for outside gage values 1.00 - 3.59

USE RATING April 4, 2013 to _____

Rating prepared by Charles Sauvageau June 21, 2013

Table 5.2-2. Grant Creek (GC200) discharge measurement summary for the 2013 season.

Q Meas #	Date	Stream Gage Water Level (ft)	Measured Discharge (ft^3/s)	Calculated Discharge (ft^3/s)	Percent Difference (meas/calc)	Comments
				Rating 1 LF		
1	4/4/2013	0.45	18.3	18.9	-3.3%	
2	4/19/2013	0.41	16.6	16.1	2.8%	
3	5/3/2013	0.64	34.3	34.3	0.0%	
4	5/9/2013	0.88	59.6	58.4	2.0%	
5	5/10/2013	0.93	63.1	64.0	-1.5%	
				Rating 1 HF		
6_{HF}	5/14/2013	1.40	145.5	152.7	-4.7%	
7_{HF}	6/12/2013	2.84	694.0	680.4	2.0%	
8_{HF}	8/21/2013	2.00	312.2	324.6	-3.8%	
9_{HF}	9/27/2013	1.78	257.6	253.7	1.5%	
10_{HF}	10/11/2013	1.49	167.4	174.2	-3.9%	

Historical Stream Gaging

A summary of USGS stream gaging records at Grant Creek from 1948-1958 and 1982-1983 are also provided in Appendix 2b. These summarized data include an 11 year average of mean/minimum/maximum daily flow statistics as well as discharge hydrographs. Based on the 2013 data, mean daily discharges follow a similar pattern as the 11 year average (Figure 5.2-1). There are two deviations in the 2013 mean daily flow record when compared to the 11 year record. In late May through the entire month of June, the ascending limb of the hydrograph is steeper and flows are maintained at a detectably higher volume above the USGS average. Secondly, the descending limb of the hydrograph shows a detectable increase in stream flows starting in early September that continues into the middle of the month.

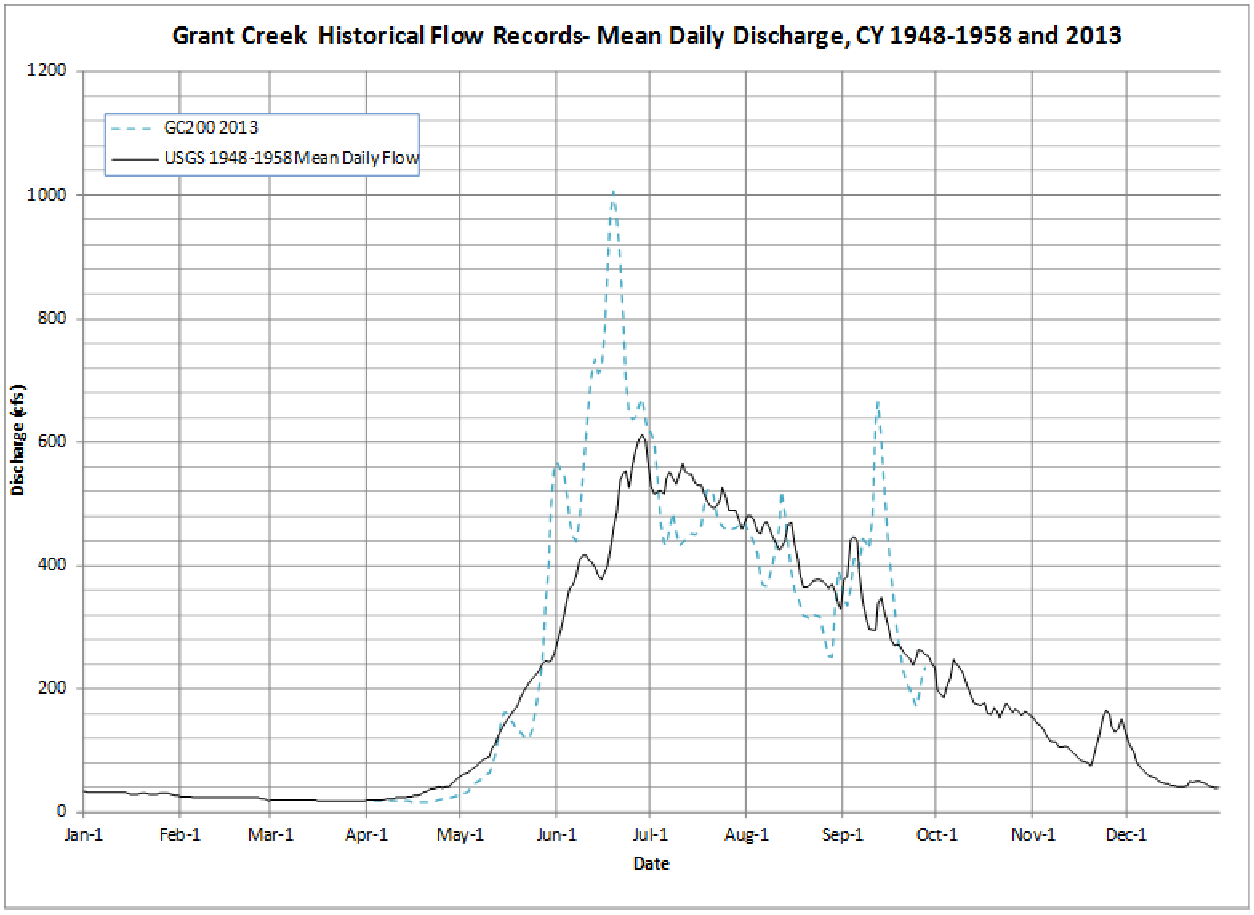


Figure 5.2-1. Comparison of historical and 2013 mean daily flow records

Accretion Study

April 4- 5, 2013, discharge measurements were taken at cross sections at the top and bottom of the Canyon Reach. Due to limited daylight and winter conditions, the upper and lower reaches of the Canyon could not be accessed in a single day. However, as seen in Figure 5.2-2, the hydrograph for April 4th-5th indicate stable flow conditions. The results show that there was 18.1 cfs and 18.3 cfs at the upstream and downstream segments of the Canyon Reach respectively (Tables 5.2-3 and 5.2-4). Results of this effort indicate that no water is lost or gained as it is conveyed down the canyon under low flow conditions. As snowmelt occurs in the spring and flows begin to increase rapidly, there may be some seeps or small runoff channels that enter the Canyon Reach. However, the accretion volumes of these seasonal channels are unlikely to increase flows in the lower section of the Canyon by more than a few cfs.

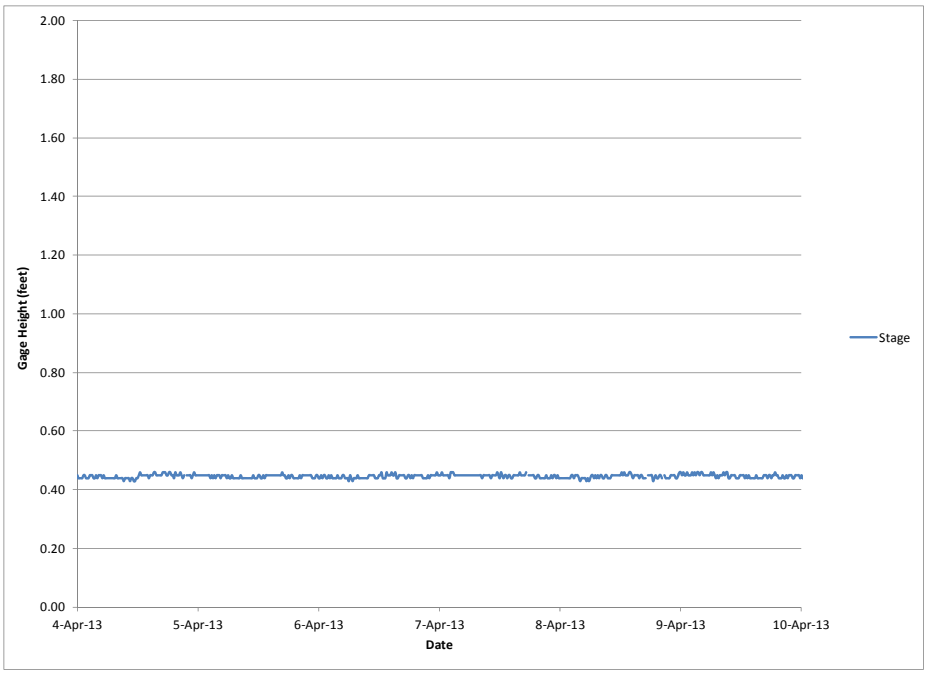


Figure 5.2-2. 15 minute stage hydrograph during accretions studies April 4-5, 2013

Table 5.2-3. Detailed discharge calculation at cross section near upper Grant Creek Canyon Reach.

							Outside Gage	H350 Recorder	HDR Staff on LBA			
Stream Name:	**Grant Creek**											Load M
Location:	**U/S end of Canyon Reach**				**Time Start:**	11:25 AM	0.45	0.45	-0.37			
Q Transect:	500' D/S Grant Lake Outlet				**Time Finish:**	12:01 PM	0.45	0.45	-0.37			
Date:	4/5/2013											
Field Crew:	CS,TR							**Discharge:**	18.1			
Station	**Depth**	**Vel 1**	**Vel 2**	**Vector**	**Comment**	**Vel. Avg.**	**Width**	**Area**	**Corr. Vel.**	**Cell Q**		**% of Q**
22.6	0.00	0.00			LBWE	0.00	0.40	0.00	0.00	0.00		0.00%
23.4	0.30	0.02				0.02	0.90	0.27	0.02	0.01		0.03%
24.4	0.70	0.14				0.14	0.90	0.63	0.14	0.09		0.49%
25.2	1.10	0.39	0.12			0.26	0.80	0.88	0.26	0.22		1.24%
26.0	1.40	0.67				0.67	0.80	1.12	0.67	0.75		4.14%
26.8	1.70	1.01				1.01	0.80	1.36	1.01	1.37		7.57%
27.6	1.90	0.82				0.82	0.80	1.52	0.82	1.25		6.87%
28.4	1.90	0.25				0.25	0.60	1.14	0.25	0.29		1.57%
28.8	1.70	1.01				1.01	0.40	0.68	1.01	0.69		3.79%
29.2	1.30	1.99				1.99	0.60	0.78	1.99	1.55		8.55%
30.0	1.25	1.41				1.41	0.60	0.75	1.41	1.06		5.83%
30.4	1.30	0.88				0.88	0.40	0.52	0.88	0.46		2.52%
30.8	1.10	0.43				0.43	0.60	0.66	0.43	0.28		1.56%
31.6	1.70	0.51				0.51	0.80	1.36	0.51	0.69		3.82%
32.4	1.30	0.73				0.73	0.80	1.04	0.73	0.76		4.18%
33.2	0.80	0.60				0.60	0.80	0.64	0.60	0.38		2.12%
34.0	0.90	0.72				0.72	0.60	0.54	0.72	0.39		2.14%
34.4	0.70	1.10				1.10	0.40	0.28	1.10	0.31		1.70%
34.8	0.65	1.47				1.47	0.40	0.26	1.47	0.38		2.11%
35.2	0.70	2.02				2.02	0.80	0.56	2.02	1.13		6.23%
36.4	0.70	2.67				2.67	0.80	0.56	2.67	1.50		8.24%
36.8	0.60	2.11				2.11	0.40	0.24	2.11	0.51		2.79%
37.2	0.80	1.57				1.57	0.60	0.48	1.57	0.75		4.15%
38.0	0.95	1.43				1.43	0.80	0.76	1.43	1.09		5.99%
38.8	1.05	0.53				0.53	0.80	0.84	0.53	0.45		2.45%
39.6	0.30	0.75				0.75	0.80	0.24	0.75	0.18		0.99%
40.4	0.20	0.69				0.69	0.80	0.16	0.69	0.11		0.61%
41.2	0.20	0.42				0.42	0.80	0.16	0.42	0.07		0.37%
42.0	0.30	0.67				0.67	0.60	0.18	0.67	0.12		0.66%
42.4	0.00	0.00				0.00	1.30	0.00	0.00	0.00		0.00%
44.6	0.00	0.00				0.00	1.50	0.00	0.00	0.00		0.00%
45.4	0.80	0.07				0.07	0.90	0.72	0.07	0.05		0.28%
46.4	0.90	0.07				0.07	1.00	0.90	0.07	0.06		0.35%
47.4	0.80	0.7				0.70	1.00	0.80	0.70	0.56		3.09%
48.4	0.70	0.38				0.38	1.00	0.70	0.38	0.27		1.47%
49.4	0.30	0.54				0.54	1.00	0.30	0.54	0.16		0.89%
50.4	0.50	0.44				0.44	1.00	0.50	0.44	0.22		1.21%
51.4	0.00	0.00			RBWE	0.00	0.50	0.00	0.00	0.00		0.00%

Table 5.2-4. Detailed discharge calculation at cross section near lower Grant Creek Canyon Reach.

							Outside Gage	H350 Recorder	HDR Staff on LBA			
Stream Name:	**Grant Creek**											Load M
Location:	**D/S end of Canyon Reach**				**Time Start:**	1:38 PM	0.45	0.45	-0.37			
Q Transect:	near ISF Transect 430				**Time Finish:**	2:07 PM	0.45	0.45	-0.37			
Date:	4/4/2013											
Field Crew:	CS,TR							**Discharge:**		18.3		
Station	**Depth**	**Vel 1**	**Vel 2**	**Vector**	**Comment**	**Vel. Avg.**	**Width**	**Area**	**Corr. Vel.**	**Cell Q**		**% of Q**
4.9	0.00	0.00			LBWE	0.00	0.55	0.00	0.00	0.00		0.00%
6.0	0.30	0.04				0.04	1.30	0.39	0.04	0.02		0.09%
7.5	0.25	0.02				0.02	1.20	0.30	0.02	0.01		0.03%
8.4	0.00	0.00				0.00	1.00	0.00	0.00	0.00		0.00%
9.5	0.00	0.00				0.00	0.80	0.00	0.00	0.00		0.00%
10.0	0.40	0.21				0.21	0.75	0.30	0.21	0.06		0.34%
11.0	0.70	1.15				1.15	0.85	0.60	1.15	0.68		3.74%
11.7	1.00	1.42				1.42	0.70	0.70	1.42	0.99		5.43%
12.4	1.05	1.28				1.28	0.70	0.74	1.28	0.94		5.14%
13.1	1.10	1.92				1.92	0.70	0.77	1.92	1.48		8.07%
13.8	1.30	1.47				1.47	0.70	0.91	1.47	1.34		7.30%
14.5	0.45	1.90				1.90	0.70	0.32	1.90	0.60		3.27%
15.2	0.80	2.23				2.23	0.70	0.56	2.23	1.25		6.82%
15.9	0.75	1.08				1.08	0.70	0.53	1.08	0.57		3.10%
16.6	1.05	0.61				0.61	0.70	0.74	0.61	0.45		2.45%
17.3	1.05	1.97				1.97	0.70	0.73	1.97	1.45		7.91%
18.0	1.05	1.63				1.63	0.70	0.73	1.63	1.20		6.54%
18.7	0.90	1.67				1.67	0.70	0.63	1.67	1.05		5.74%
19.4	0.90	1.07				1.07	0.70	0.63	1.07	0.67		3.68%
20.1	0.70	1.62				1.62	0.70	0.49	1.62	0.79		4.33%
20.8	0.90	1.20				1.20	0.70	0.63	1.20	0.76		4.13%
21.5	0.80	0.95				0.95	0.70	0.56	0.95	0.53		2.90%
22.2	0.60	1.05				1.05	0.70	0.42	1.05	0.44		2.41%
22.9	0.55	1.18				1.18	0.70	0.39	1.18	0.45		2.48%
23.6	0.60	0.72				0.72	0.70	0.42	0.72	0.30		1.65%
24.3	0.65	1.15				1.15	0.70	0.46	1.15	0.52		2.86%
25.0	0.60	0.61				0.61	0.70	0.42	0.61	0.26		1.40%
25.7	0.40	1.01				1.01	0.70	0.28	1.01	0.28		1.54%
26.4	0.50	1.36				1.36	0.70	0.35	1.36	0.48		2.60%
27.1	0.55	0.95				0.95	0.70	0.39	0.95	0.37		2.00%
27.8	0.50	0.47				0.47	0.70	0.35	0.47	0.16		0.90%
28.5	0.50	0.38				0.38	0.70	0.35	0.38	0.13		0.73%
29.2	0.60	0.02				0.02	0.85	0.51	0.02	0.01		0.06%
30.2	0.40	0.11				0.11	0.55	0.22	0.11	0.02		0.13%
30.3	0.00	0.00				0.00	0.50	0.00	0.00	0.00		0.00%
31.2	0.00	0.00				0.00	0.55	0.00	0.00	0.00		0.00%
31.4	0.40	0.01				0.01	0.40	0.16	0.01	0.00		0.01%
32.0	0.50	0.01				0.01	0.55	0.28	0.01	0.00		0.02%
32.5	0.00	0.00				0.00	0.80	0.00	0.00	0.00		0.00%
33.6	0.00	0.00				0.00	0.60	0.00	0.00	0.00		0.00%
33.7	0.20	0.01				0.01	0.70	0.14	0.01	0.00		0.01%
35.0	0.20	0.13				0.13	1.15	0.23	0.13	0.03		0.16%
36.0	0.20	0.04				0.04	1.30	0.26	0.04	0.01		0.06%
37.6	0.00	0.00			RBWE	0.00	0.80	0.00	0.00	0.00		0.00%

6 CONCLUSIONS

6.1. Water Quality and Temperature

Water Quality

The Grant Lake watershed which includes Grant Creek and Trail Lake Narrows is a high quality watershed based on ADEC water quality criteria. The Trail Lake Narrows flows directly past the mouth of Grant Creek and receives additive flow from it to combine with the majority of its

existing water coming from Upper Trail Lake. Baseline water quality sampling results from 2009, 2010 and 2013 indicate this watershed has excellent water quality which is to be expected due to its remote location and pristine condition. Human impacts appear minimal throughout the watershed. Where impacts are occurring, they are primarily associated with the community of Moose Pass and the Trail Lakes themselves. In addition to its current excellent water quality, a comparison of sampling results from the three sampling years for all sites indicates little or no changes in water quality has occurred over the five year period for nearly all parameters. Two notable exceptions were dissolved oxygen and pH.

Dissolved oxygen results (both mg/l and percent saturation values) for 2013 were similar to those collected in 1981 (AEIDC 1983) for Grant Lake but higher in Grant Creek when compared to the 1981 data. The 2013 and 1981 dissolved oxygen levels were substantially different (higher) than those collected in 2009 and 2010. A Grant Lake oxygen profile in June 1981 (AEIDC 1983) found levels ranged from 11.3-12.2 mg/l from the surface to 50 feet deep (Appendix 3). Tables 4-2 through 4-6 provide the 2009 thru 2013 dissolved oxygen results. As stated in the results sections, the lower dissolved oxygen levels measured during 2009-2010 were most likely due to faulty probes or poor calibration procedures. Sampling efforts in 2013 deployed separate multi-probe instruments at each site to achieve more reliable results. Based on the 1981 and 2013 results, dissolved oxygen concentrations are at or near saturation throughout the water column. All other *in situ* parameter sampling results were similar when comparing 1981, 2009/2010 and 2013 data.

In summary and based upon our comprehensive assessment, the water quality parameters in Grant Lake and Grant Creek are very similar and in such low concentrations, that the proposed seasonal changes in Grant Lake outflows as a result of the proposed Project would have very little impact on the water chemistry of Grant Creek.

Temperature

Grant Creek exhibits the typical characteristics of a south central Alaskan, temperate forest stream. Typically, low flows occur in winter (generally November through April) when ice and snow cover keep overland water sources frozen. Ambient air temperatures appear to directly affect stream temperatures throughout the year. However, the extreme upper end of Grant Creek appears to receive some buffering from extreme late winter air temperatures due to its proximity to outflows from an ice covered Grant Lake. During periods of ice cover, the lake temperatures are much more stable compared to Grant Creek temperatures. Once the lake becomes ice free, ambient air temperatures begin to influence daily mean water temperatures in the upper portions of the water column of the lake and this in turn, directly influences creek water temperatures.

Generally in late spring (mid-May), air temperatures warm due to extended periods of daylight and ice begins to break up on Grant Lake. Once breakup occurs, the stream temperatures are closely correlated to lake water temperatures at a depth of 1.5 meters. Temperatures peak in August as runoff flows recede and lake temperatures increase. This also coincides with the majority of anadromous fish returning to the stream to spawn. Stream temperatures steadily descend throughout the fall.

Grant Lake vertical temperature profiles show two distinct characteristics that are typical for lakes that experience long periods of ice cover (Bengtsson 2012). The first characteristic noted is that winter water temperatures increase with depth. This trend was noted from January through mid to late May. Following ice breakup temperatures begin to warm up on the surface and remain cooler at depth. The largest temperature difference between the lake surface and at depth occurs in mid August through mid September. By late September the water column is of Grant Lake is nearly isothermic. The onset and duration of ice cover appears to have a substantial effect on the timing of Grant Lake temperature changes.

Baseline temperature data for both Grant Creek and Grant Lake were collected to assist in development of Project design and potential mitigation measures. Proposed Project designs indicate water withdrawals from Grant Lake would occur near the GLTS site (Figure 3.1-1). A review of 2009 and 2013 water temperature data from Grant Creek and Grant Lake indicates a depth of 1.5 meters below the water surface in Grant Lake most closely mimics water temperatures in Grant Creek (Figures 5.1-7 and 5.1-8).

6.2. Hydrology

The primary study objectives of extending the period of record and assessing accretion flows within the canyon reach of Grant Creek were achieved. Discharge measurements ranging from 17 cfs to 694 cfs were completed and accurately defined the stage-discharge relationship. The 2013 discharge record was similar to the historical USGS record with a few deviations from the general pattern in June and September 2013. The higher flows in June most likely resulted from a sustained heat wave. These warm temperatures resulted in elevated rates of snow and glacial melt which caused higher discharges. In September 2013, a pattern of sustained precipitation is what caused flows to spike above the 11 year average.

A period of stable, low flow conditions in early April allowed for the accurate measurement of discharge at the upstream and downstream sections of the Canyon Reach. The results indicate that all of the water entering the canyon reach is conveyed downstream, with no net losses or gains for the 0.5 mile section of Grant Creek.

7 VARIANCES FROM FERC-APPROVED STUDY PLAN AND PROPOSED MODIFICATIONS

7.1. Water Quality and Temperature

There were no substantial variances from the FERC and agency-approved study plan.

7.2. Hydrology

There were no substantial variances from the FERC and agency-approved study plan.

8 REFERENCES

AEIDC (Arctic Environmental Information Data Center). 1983. *Summary of environmental knowledge of the proposed Grant Lake hydroelectric project area*. Final Report submitted to Ebasco Services, Inc., Redmond, Washington, University of Alaska, Anchorage, Alaska.

Bengtsson, L., R.W. Herschy and R.W Fairbridge. 2012. Encyclopedia of Lakes and Reservoirs. Department of Water Resources Engineering, Lund University, Lund, Sweden. 954 pgs.

Ebasco Services Incorporated. 1984. Grant Lake Hydroelectric Project Detailed Feasibility Analysis. Volume 2. Environmental Report. Rep. prepared for Alaska Power Authority.

HDR. 2009. Grant Creek Proposed Hydroelectric Project Reconnaissance Report, Draft. Prepared For Kenai Hydro, LLC, Homer, Alaska.

HDR. 2010. Grant Lake/Grant Creek And Falls Creek Project - Aquatic Resources Draft Study plan. Prepared For Kenai Hydro, LLC, Homer, Alaska.

KHL (Kenai Hydro, LLC). 2009. Pre-Application Document Grant Lake/Grant Creek and Falls Creek Project (FERC No. 13211 and 13212). August 2009.

Rantz, S.E., and others. 1982. Measurement and Computation of Streamflow, Volume 1: Measurement of Stage and Discharge. U.S. Geological Survey Water Supply Paper 2175.

[This page intentionally left blank.]

Appendix 1: Grant Lake and Grant Creek Temperature Records

Appendix 1a. Grant Creek Temperature Records - 2013

Appendix 1b. Grant Lake Temperature Records – 2013

Appendix 1c. Historical Grant Creek Temperature Records – 1982; 2009-2012

Appendix 1d. Historical Grant Lake Temperature Records – 2010-2012

Appendix 1a. Grant Creek Temperature Records – 2013

This appendix contains the following figures and tables:

Table A.1a-1. Grant Creek – GC 100 daily mean temperature (C), calendar year 2013.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	m	m	m	m	2.2	4.2	9.7	13.9	12.6	m	m	m
2	m	m	m	1.6	2.0	4.6	10.1	14.7	12.2	m	m	m
3	m	m	m	1.1	2.2	4.7	9.9	14.7	12.1	m	m	m
4	m	m	m	0.9	2.1	5.4	9.5	13.3	11.7	m	m	m
5	m	m	m	0.7	2.5	5.3	10.0	13.4	11.6	m	m	m
6	m	m	m	1.1	2.7	6.1	10.5	13.4	11.5	m	m	m
7	m	m	m	0.8	2.8	5.7	10.5	13.6	11.4	m	m	m
8	m	m	m	0.5	2.9	5.8	10.4	12.3	11.3	m	m	m
9	m	m	m	0.5	3.0	7.0	10.5	12.6	11.2	m	m	m
10	m	m	m	0.2	3.2	8.1	11.8	12.4	11.2	m	m	m
11	m	m	m	0.1	3.3	9.2	12.6	12.3	11.2	m	m	m
12	m	m	m	0.3	3.4	8.1	12.9	12.8	10.5	m	m	m
13	m	m	m	0.4	3.4	8.4	11.1	12.6	10.7	m	m	m
14	m	m	m	0.7	3.3	9.1	11.5	12.9	10.8	m	m	m
15	m	m	m	0.7	3.4	9.8	13.1	13.1	10.9	m	m	m
16	m	m	m	0.7	3.6	11.3	13.7	13.2	10.7	m	m	m
17	m	m	m	0.7	3.7	12.4	14.6	13.8	10.6	m	m	m
18	m	m	m	0.8	3.7	11.1	14.3	13.5	10.5	m	m	m
19	m	m	m	0.9	3.9	11.6	13.7	13.0	10.4	m	m	m
20	m	m	m	1.0	4.0	9.8	14.9	12.6	9.9	m	m	m
21	m	m	m	1.2	4.1	8.4	15.7	12.1	9.6	m	m	m
22	m	m	m	1.6	4.3	10.5	14.4	12.3	9.3	m	m	m
23	m	m	m	1.4	4.6	10.9	14.2	12.8	8.9	m	m	m
24	m	m	m	1.8	4.9	11.8	14.2	13.1	8.7	m	m	m
25	m	m	m	1.6	4.9	11.9	13.4	12.9	8.8	m	m	m
26	m	m	m	1.4	4.8	11.8	13.5	12.7	8.8	m	m	m
27	m	m	m	1.6	5.0	11.3	14.5	13.2	m	m	m	m
28	m	m	m	1.6	5.0	11.3	15.0	12.6	m	m	m	m
29	m	---	m	1.7	5.0	11.8	15.2	13.3	m	m	m	m
30	m	---	m	1.9	4.8	10.1	14.8	13.2	m	m	m	m
31	m	---	m	---	4.3	---	14.7	12.7	---	m	---	m
Mean	m	m	m	1.0	3.6	8.9	12.7	13.1	10.6	m	m	m
Min	m	m	m	0.1	2.0	4.2	9.5	12.1	8.7	m	m	m
Max	m	m	m	1.9	5.0	12.4	15.7	14.7	12.6	m	m	m

Notes: m – missing data

Table A.1a-2. Grant Creek – GC 200 daily mean temperature (C), calendar year 2013.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1.6	1.4	1.4	1.3	2.0	4.2	9.7	13.9	12.5	m	m	m
2	1.6	1.5	1.0	0.6	1.9	4.5	10.0	14.7	12.1	m	m	m
3	1.6	1.4	1.3	m	2.1	4.7	9.9	14.6	12.1	m	m	m
4	1.6	1.5	1.5	1.3	2.1	5.3	9.5	13.2	11.7	m	m	m
5	1.7	1.4	1.4	0.6	2.4	5.3	10.0	13.4	11.5	m	m	m
6	1.6	1.3	1.3	1.0	2.5	6.0	10.5	13.3	11.5	m	m	m
7	1.5	1.3	1.4	0.6	2.6	5.6	10.4	13.6	11.4	m	m	m
8	1.4	1.4	1.5	0.2	2.7	5.8	10.4	12.3	11.2	m	m	m
9	0.9	1.4	1.4	0.2	2.9	7.0	10.5	12.6	11.1	m	m	m
10	1.2	1.5	1.1	0.0	3.0	8.0	11.7	12.4	11.2	m	m	m
11	1.3	1.2	1.1	0.1	3.2	9.2	12.6	12.2	11.1	m	m	m
12	1.3	1.2	0.5	0.2	3.2	8.1	12.9	12.8	10.5	m	m	m
13	1.5	1.4	0.3	0.3	3.2	8.4	11.0	12.6	10.6	m	m	m
14	1.5	1.5	0.7	0.5	3.2	9.1	11.4	12.8	10.8	m	m	m
15	1.1	1.4	0.6	0.4	3.4	9.7	13.0	13.1	10.9	m	m	m
16	1.0	0.7	0.3	0.4	3.4	11.2	13.6	13.2	10.6	m	m	m
17	0.9	1.2	0.4	0.4	3.6	12.4	14.5	13.7	10.6	m	m	m
18	0.6	0.8	0.3	0.4	3.6	11.1	14.3	13.4	10.5	m	m	m
19	1.1	0.8	0.3	0.6	3.8	11.5	13.6	13.0	10.3	m	m	m
20	1.2	1.3	0.3	0.7	3.9	9.8	14.9	12.5	9.8	m	m	m
21	1.3	1.1	0.3	1.0	4.0	8.4	15.6	12.1	9.5	m	m	m
22	1.5	1.0	0.5	1.3	4.2	10.4	14.4	12.3	9.2	m	m	m
23	1.5	1.0	1.1	1.3	4.5	10.9	14.2	12.8	8.8	m	m	m
24	1.4	1.2	1.0	1.7	4.8	11.8	14.1	13.0	8.6	m	m	m
25	1.1	1.2	0.7	1.5	4.8	11.9	13.3	12.8	8.7	m	m	m
26	0.1	1.3	0.4	1.3	4.7	11.7	13.4	12.7	8.7	m	m	m
27	0.1	1.4	0.2	1.4	4.9	11.3	14.5	13.1	m	m	m	m
28	0.1	1.5	0.9	1.4	4.9	11.2	14.9	12.6	m	m	m	m
29	0.9	---	1.1	1.6	4.9	11.8	15.2	13.2	m	m	m	m
30	1.3	---	1.3	1.8	4.7	10.1	14.7	13.2	m	m	m	m
31	1.3	---	1.3	---	4.2	---	14.6	12.7	---	m	---	m
Mean	1.2	1.3	0.9	0.9	3.5	8.9	12.7	13.0	10.6	m	m	m
Min	0.1	0.7	0.2	0.0	1.9	4.2	9.5	12.1	8.6	m	m	m
Max	1.7	1.5	1.5	1.8	4.9	12.4	15.6	14.7	12.5	m	m	m

Notes: m – missing data

Table A.1a-3. Grant Creek – GC 250 daily mean temperature (C), calendar year 2013.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	m	m	m	m	2.1	4.2	9.7	13.9	12.5	m	m	m
2	m	m	m	1.5	2.0	4.5	10.1	14.7	12.2	m	m	m
3	m	m	m	1.1	2.2	4.7	9.9	14.7	12.1	m	m	m
4	m	m	m	0.9	2.1	5.4	9.5	13.3	11.7	m	m	m
5	m	m	m	0.8	2.5	5.3	10.0	13.4	11.6	m	m	m
6	m	m	m	1.1	2.6	6.1	10.5	13.4	11.5	m	m	m
7	m	m	m	0.8	2.7	5.6	10.5	13.6	11.4	m	m	m
8	m	m	m	0.5	2.8	5.8	10.4	12.3	11.2	m	m	m
9	m	m	m	0.5	3.0	7.0	10.5	12.6	11.2	m	m	m
10	m	m	m	0.3	3.2	8.1	11.8	12.4	11.2	m	m	m
11	m	m	m	0.2	3.3	9.2	12.6	12.3	11.2	m	m	m
12	m	m	m	0.3	3.3	8.1	12.9	12.8	10.5	m	m	m
13	m	m	m	0.5	3.4	8.4	11.0	12.6	10.6	m	m	m
14	m	m	m	0.8	3.3	9.1	11.5	12.9	10.8	m	m	m
15	m	m	m	0.7	3.4	9.8	13.1	13.1	10.9	m	m	m
16	m	m	m	0.7	3.6	11.3	13.7	13.2	10.7	m	m	m
17	m	m	m	0.8	3.7	12.4	14.6	13.8	10.6	m	m	m
18	m	m	m	0.8	3.7	11.1	14.3	13.5	10.5	m	m	m
19	m	m	m	0.9	3.9	11.6	13.6	13.0	10.4	m	m	m
20	m	m	m	1.0	4.0	9.8	14.9	12.5	9.9	m	m	m
21	m	m	m	1.1	4.1	8.4	15.7	12.2	9.6	m	m	m
22	m	m	m	1.5	4.3	10.5	14.4	12.3	9.3	m	m	m
23	m	m	m	1.4	4.6	10.9	14.2	12.8	8.9	m	m	m
24	m	m	m	1.7	4.9	11.8	14.2	13.1	8.7	m	m	m
25	m	m	m	1.5	4.9	11.9	13.3	12.9	8.8	m	m	m
26	m	m	m	1.4	4.7	11.8	13.4	12.7	8.8	m	m	m
27	m	m	m	1.5	5.0	11.3	14.5	13.2	m	m	m	m
28	m	m	m	1.5	5.0	11.3	15.0	12.6	m	m	m	m
29	m	---	m	1.7	5.0	11.8	15.2	13.3	m	m	m	m
30	m	---	m	1.8	4.8	10.1	14.8	13.2	m	m	m	m
31	m	---	m	---	4.2	---	14.7	12.7	---	m	---	m
Mean	m	m	m	1.0	3.6	8.9	12.7	13.1	10.6	m	m	m
Min	m	m	m	0.2	2.0	4.2	9.5	12.2	8.7	m	m	m
Max	m	m	m	1.8	5.0	12.4	15.7	14.7	12.5	m	m	m

Notes: m – missing data

Table A.1a-4. Grant Creek – GC 300 daily mean temperature (C), calendar year 2013.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	m	m	m	m	2.0	4.2	9.6	13.8	12.5	m	m	m
2	m	m	m	1.4	1.9	4.5	10.0	14.7	12.1	m	m	m
3	m	m	m	1.1	2.1	4.7	9.9	14.6	12.1	m	m	m
4	m	m	m	0.9	2.1	5.3	9.4	13.2	11.7	m	m	m
5	m	m	m	0.8	2.4	5.3	10.0	13.4	11.5	m	m	m
6	m	m	m	1.1	2.6	6.0	10.5	13.4	11.5	m	m	m
7	m	m	m	0.8	2.7	5.6	10.4	13.6	11.4	m	m	m
8	m	m	m	0.5	2.7	5.7	10.4	12.3	11.2	m	m	m
9	m	m	m	0.5	2.9	7.0	10.5	12.6	11.2	m	m	m
10	m	m	m	0.4	3.1	8.1	11.7	12.4	11.2	m	m	m
11	m	m	m	0.2	3.2	9.1	12.6	12.2	11.2	m	m	m
12	m	m	m	0.4	3.3	8.1	12.8	12.8	10.5	m	m	m
13	m	m	m	0.5	3.3	8.4	11.0	12.5	10.6	m	m	m
14	m	m	m	0.7	3.3	9.1	11.4	12.8	10.8	m	m	m
15	m	m	m	0.7	3.4	9.8	13.1	13.1	10.9	m	m	m
16	m	m	m	0.7	3.6	11.3	13.6	13.2	10.6	m	m	m
17	m	m	m	0.8	3.6	12.3	14.5	13.7	10.6	m	m	m
18	m	m	m	0.8	3.7	11.0	14.2	13.5	10.5	m	m	m
19	m	m	m	0.9	3.8	11.5	13.6	13.0	10.4	m	m	m
20	m	m	m	1.0	3.9	9.8	14.9	12.5	9.9	m	m	m
21	m	m	m	1.1	4.0	8.4	15.6	12.1	9.6	m	m	m
22	m	m	m	1.4	4.2	10.5	14.3	12.3	9.3	m	m	m
23	m	m	m	1.3	4.5	10.9	14.1	12.8	8.9	m	m	m
24	m	m	m	1.6	4.8	11.8	14.1	13.1	8.7	m	m	m
25	m	m	m	1.5	4.8	11.9	13.3	12.8	8.8	m	m	m
26	m	m	m	1.3	4.7	11.7	13.4	12.7	8.7	m	m	m
27	m	m	m	1.4	4.9	11.2	14.5	13.2	m	m	m	m
28	m	m	m	1.5	4.9	11.2	14.9	12.6	m	m	m	m
29	m	---	m	1.6	4.9	11.7	15.2	13.3	m	m	m	m
30	m	---	m	1.8	4.7	10.0	14.7	13.2	m	m	m	m
31	m	---	m	---	4.2	---	14.6	12.7	---	m	---	m
Mean	m	m	m	1.0	3.6	8.9	12.7	13.0	10.6	m	m	m
Min	m	m	m	0.2	1.9	4.2	9.4	12.1	8.7	m	m	m
Max	m	m	m	1.8	4.9	12.3	15.6	14.7	12.5	m	m	m

Notes: m – missing data

Table A.1a-5. Grant Creek – GC 500 daily mean temperature (C), calendar year 2013.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	m	m	m	m	2.0	4.2	9.6	13.8	12.5	m	m	m
2	m	m	m	1.3	1.9	4.4	10.0	14.7	12.1	m	m	m
3	m	m	m	1.1	2.1	4.7	9.9	14.6	12.0	m	m	m
4	m	m	m	0.9	2.1	5.3	9.4	13.2	11.7	m	m	m
5	m	m	m	0.8	2.4	5.3	10.0	13.4	11.5	m	m	m
6	m	m	m	1.1	2.5	6.0	10.5	13.3	11.5	m	m	m
7	m	m	m	0.8	2.6	5.5	10.4	13.6	11.3	m	m	m
8	m	m	m	0.6	2.7	5.7	10.4	12.3	11.2	m	m	m
9	m	m	m	0.6	2.9	7.0	10.5	12.6	11.1	m	m	m
10	m	m	m	0.4	3.1	8.1	11.7	12.4	11.2	m	m	m
11	m	m	m	0.3	3.2	9.1	12.6	12.2	11.1	m	m	m
12	m	m	m	0.4	3.2	8.0	12.8	12.8	10.5	m	m	m
13	m	m	m	0.5	3.3	8.3	10.9	12.5	10.6	m	m	m
14	m	m	m	0.8	3.3	9.0	11.4	12.8	10.8	m	m	m
15	m	m	m	0.8	3.4	9.7	13.1	13.1	10.9	m	m	m
16	m	m	m	0.7	3.6	11.2	13.6	13.2	10.6	m	m	m
17	m	m	m	0.8	3.6	12.3	14.5	13.7	10.6	m	m	m
18	m	m	m	0.8	3.6	11.0	14.2	13.4	10.5	m	m	m
19	m	m	m	0.9	3.8	11.5	13.6	13.0	10.4	m	m	m
20	m	m	m	1.0	3.9	9.7	14.9	12.5	9.9	m	m	m
21	m	m	m	1.1	4.0	8.3	15.6	12.1	9.6	m	m	m
22	m	m	m	1.3	4.1	10.4	14.3	12.3	9.3	m	m	m
23	m	m	m	1.3	4.4	10.9	14.1	12.8	8.9	m	m	m
24	m	m	m	1.6	4.8	11.7	14.1	13.1	8.7	m	m	m
25	m	m	m	1.4	4.8	11.9	13.3	12.8	8.8	m	m	m
26	m	m	m	1.3	4.7	11.7	13.4	12.7	8.7	m	m	m
27	m	m	m	1.4	4.9	11.2	14.5	13.1	m	m	m	m
28	m	m	m	1.4	4.8	11.2	14.9	12.6	m	m	m	m
29	m	---	m	1.6	4.9	11.7	15.2	13.3	m	m	m	m
30	m	---	m	1.8	4.7	10.0	14.7	13.2	m	m	m	m
31	m	---	m	---	4.1	---	14.6	12.7	---	m	---	m
Mean	m	m	m	1.0	3.5	8.8	12.7	13.0	10.6	m	m	m
Min	m	m	m	0.3	1.9	4.2	9.4	12.1	8.7	m	m	m
Max	m	m	m	1.8	4.9	12.3	15.6	14.7	12.5	m	m	m

Notes: m – missing data

Table A.1a-6. Grant Creek – GC 600 daily mean temperature (C), calendar year 2013.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	m	m	m	m	1.8	4.1	9.6	13.8	12.4	m	m	m
2	m	m	m	m	1.8	4.4	10.0	14.8	12.0	m	m	m
3	m	m	m	m	1.9	4.6	9.9	14.6	11.9	m	m	m
4	m	m	m	m	2.0	5.2	9.4	13.2	11.5	m	m	m
5	m	m	m	1.3	2.3	5.3	9.9	13.3	11.4	m	m	m
6	m	m	m	1.1	2.4	5.9	10.4	13.4	11.3	m	m	m
7	m	m	m	1.1	2.5	5.5	10.4	13.6	11.2	m	m	m
8	m	m	m	1.0	2.6	5.6	10.3	12.3	11.0	m	m	m
9	m	m	m	1.1	2.8	6.9	10.5	12.6	11.0	m	m	m
10	m	m	m	1.0	2.9	8.0	11.7	12.3	11.0	m	m	m
11	m	m	m	1.0	3.0	9.1	12.7	12.2	11.0	m	m	m
12	m	m	m	1.0	3.1	8.0	12.8	12.7	10.3	m	m	m
13	m	m	m	1.0	3.2	8.3	10.8	12.5	10.4	m	m	m
14	m	m	m	1.1	3.3	9.0	11.4	12.8	10.6	m	m	m
15	m	m	m	1.1	3.4	9.7	13.1	13.1	10.8	m	m	m
16	m	m	m	1.1	3.5	11.2	13.7	13.2	10.6	m	m	m
17	m	m	m	1.1	3.6	12.5	14.6	13.7	10.5	m	m	m
18	m	m	m	1.1	3.6	11.0	14.2	13.4	10.4	m	m	m
19	m	m	m	1.1	3.8	11.6	13.7	12.9	10.3	m	m	m
20	m	m	m	1.2	3.9	9.7	14.9	12.5	9.9	m	m	m
21	m	m	m	1.1	4.0	8.3	15.7	12.1	9.5	m	m	m
22	m	m	m	1.2	4.1	10.5	14.3	12.2	9.2	m	m	m
23	m	m	m	1.2	4.4	10.9	14.1	12.6	8.9	m	m	m
24	m	m	m	1.3	4.8	11.7	14.1	13.0	8.7	m	m	m
25	m	m	m	1.4	4.8	11.8	13.3	12.7	8.6	m	m	m
26	m	m	m	1.4	4.7	11.7	13.3	12.7	8.6	m	m	m
27	m	m	m	1.5	4.8	11.1	14.4	13.0	m	m	m	m
28	m	m	m	1.6	4.8	11.2	14.9	12.4	m	m	m	m
29	m	---	m	1.6	4.8	11.7	15.1	13.1	m	m	m	m
30	m	---	m	1.7	4.5	10.0	14.7	13.0	m	m	m	m
31	m	---	m	---	4.0	---	14.6	12.5	---	m	---	m
Mean	m	m	m	1.2	3.5	8.8	12.7	13.0	10.5	m	m	m
Min	m	m	m	1.0	1.8	4.1	9.4	12.1	8.6	m	m	m
Max	m	m	m	1.7	4.8	12.5	15.7	14.8	12.4	m	m	m

Notes: m – missing data

Table A.1a-7. Grant Creek off-channel rearing area – GC 200oc daily mean temperature (C), calendar year 2013.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	m	m	m	m	m	m	9.5	13.4	10.0	m	m	m
2	m	m	m	m	m	m	9.5	13.0	9.9	m	m	m
3	m	m	m	m	m	m	9.3	13.0	9.8	m	m	m
4	m	m	m	m	m	m	9.2	12.8	9.7	m	m	m
5	m	m	m	m	m	m	9.0	12.5	9.4	m	m	m
6	m	m	m	m	m	m	9.1	12.3	9.3	m	m	m
7	m	m	m	m	m	m	9.3	12.1	9.2	m	m	m
8	m	m	m	m	m	m	9.5	12.2	9.2	m	m	m
9	m	m	m	m	m	m	9.6	11.7	9.2	m	m	m
10	m	m	m	m	m	m	9.7	11.8	9.2	m	m	m
11	m	m	m	m	m	m	10.2	11.7	9.2	m	m	m
12	m	m	m	m	m	m	10.6	11.8	9.1	m	m	m
13	m	m	m	m	m	m	10.9	11.9	8.9	m	m	m
14	m	m	m	m	m	8.6	10.6	11.9	9.0	m	m	m
15	m	m	m	m	m	7.9	10.7	11.7	8.8	m	m	m
16	m	m	m	m	m	8.7	11.1	11.6	8.5	m	m	m
17	m	m	m	m	m	10.5	11.3	11.6	8.5	m	m	m
18	m	m	m	m	m	10.8	11.8	11.6	8.5	m	m	m
19	m	m	m	m	m	9.7	12.3	11.7	8.4	m	m	m
20	m	m	m	m	m	9.8	12.4	11.5	7.9	m	m	m
21	m	m	m	m	m	8.9	12.7	11.1	7.6	m	m	m
22	m	m	m	m	m	8.6	13.0	10.1	7.7	m	m	m
23	m	m	m	m	m	9.5	12.8	9.8	7.4	m	m	m
24	m	m	m	m	m	10.3	12.8	9.8	6.9	m	m	m
25	m	m	m	m	m	10.5	12.9	9.7	7.0	m	m	m
26	m	m	m	m	m	10.7	12.7	9.8	7.1	m	m	m
27	m	m	m	m	m	10.9	12.8	9.9	m	m	m	m
28	m	m	m	m	m	10.3	13.2	10.1	m	m	m	m
29	m	---	m	m	m	10.5	13.4	10.3	m	m	m	m
30	m	---	m	m	m	10.5	13.6	10.0	m	m	m	m
31	m	---	m	---	m	---	13.6	10.1	---	m	---	m
Mean	m	m	m	m	m	9.8	11.3	11.4	8.7	m	m	m
Min	m	m	m	m	m	7.9	9.0	9.7	6.9	m	m	m
Max	m	m	m	m	m	10.9	13.6	13.4	10.0	m	m	m
Notes:	**m – missing data**											

Table A.1a-8. Grant Creek off channel rearing area – GC250oc daily mean temperature (C), calendar year 2013.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	m	m	m	m	m	m	m	13.7	12.3	m	m	m
2	m	m	m	m	m	m	m	14.2	11.7	m	m	m
3	m	m	m	m	m	m	m	14.4	11.8	m	m	m
4	m	m	m	m	m	m	m	13.1	11.4	m	m	m
5	m	m	m	m	m	m	m	13.2	11.2	m	m	m
6	m	m	m	m	m	m	m	13.0	11.0	m	m	m
7	m	m	m	m	m	m	m	13.3	11.1	m	m	m
8	m	m	m	m	m	m	m	12.2	10.9	m	m	m
9	m	m	m	m	m	m	m	12.3	10.6	m	m	m
10	m	m	m	m	m	m	m	12.4	10.7	m	m	m
11	m	m	m	m	m	m	m	12.2	10.2	m	m	m
12	m	m	m	m	m	m	m	12.7	9.8	m	m	m
13	m	m	m	m	m	m	m	12.6	9.8	m	m	m
14	m	m	m	m	m	m	m	12.8	9.7	m	m	m
15	m	m	m	m	m	m	m	13.0	10.3	m	m	m
16	m	m	m	m	m	m	m	12.8	9.6	m	m	m
17	m	m	m	m	m	m	m	13.4	9.5	m	m	m
18	m	m	m	m	m	m	13.4	13.1	9.6	m	m	m
19	m	m	m	m	m	m	13.5	12.7	9.8	m	m	m
20	m	m	m	m	m	m	14.6	12.3	9.4	m	m	m
21	m	m	m	m	m	m	15.3	12.0	8.9	m	m	m
22	m	m	m	m	m	m	14.3	12.0	8.6	m	m	m
23	m	m	m	m	m	m	13.9	12.6	8.3	m	m	m
24	m	m	m	m	m	m	13.9	12.8	7.8	m	m	m
25	m	m	m	m	m	m	13.1	12.5	8.2	m	m	m
26	m	m	m	m	m	m	13.3	12.3	8.3	m	m	m
27	m	m	m	m	m	m	14.2	12.9	m	m	m	m
28	m	m	m	m	m	m	14.6	12.4	m	m	m	m
29	m	---	m	m	m	m	14.8	12.7	m	m	m	m
30	m	---	m	m	m	m	14.5	12.9	m	m	m	m
31	m	---	m	---	m	---	14.3	12.4	---	m	---	m
Mean	m	m	m	m	m	m	14.1	12.8	10.0	m	m	m
Min	m	m	m	m	m	m	13.1	12.0	7.8	m	m	m
Max	m	m	m	m	m	m	15.3	14.4	12.3	m	m	m

Notes: m – missing data

Appendix 1b. Grant Lake Temperature Records – 2013

This appendix contains the following figures and tables:

Table A.1b-1. Grant Lake – GL 0.2m daily mean temperature (C), calendar year 2013.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.0	0.0	0.0	0.0	0.0	4.5	10.0	14.5	12.8	m	m	m
2	0.0	0.0	0.0	0.0	0.0	4.9	10.6	15.3	12.4	m	m	m
3	0.0	0.0	0.0	0.0	0.0	4.7	10.4	14.8	12.2	m	m	m
4	0.0	0.0	0.0	0.0	0.0	5.3	9.8	13.6	11.7	m	m	m
5	0.0	0.0	0.0	0.0	0.1	5.6	10.3	13.6	11.6	m	m	m
6	0.1	0.0	0.0	0.0	0.1	5.7	10.9	13.4	11.5	m	m	m
7	0.0	0.0	0.0	0.0	0.1	6.1	10.7	13.7	11.5	m	m	m
8	0.0	0.0	0.0	0.0	0.1	5.9	10.7	12.4	11.4	m	m	m
9	0.0	0.0	0.0	0.0	0.2	7.3	10.9	12.6	11.2	m	m	m
10	0.0	0.0	0.0	0.0	0.2	8.2	11.9	12.7	11.2	m	m	m
11	0.1	0.0	0.0	0.0	0.1	9.8	13.5	12.4	11.3	m	m	m
12	0.1	0.0	0.0	0.0	0.1	9.5	13.7	13.0	10.8	m	m	m
13	0.1	0.0	0.0	0.0	0.2	9.8	11.8	13.1	10.5	m	m	m
14	0.1	0.0	0.0	0.0	0.1	10.4	12.2	13.2	10.8	m	m	m
15	0.1	0.0	0.0	0.0	0.2	10.2	13.8	13.4	10.9	m	m	m
16	0.1	0.0	0.0	0.0	0.2	12.5	14.3	13.5	10.7	m	m	m
17	0.1	0.0	0.0	0.0	0.3	15.3	15.2	13.8	10.7	m	m	m
18	0.1	0.0	0.0	0.0	0.4	13.0	15.1	13.8	10.6	m	m	m
19	0.1	0.0	0.0	0.0	0.5	12.0	14.4	13.3	10.5	m	m	m
20	0.1	0.0	0.0	0.0	0.5	10.9	15.4	12.7	10.1	m	m	m
21	0.1	0.0	0.0	0.0	0.6	9.1	16.0	12.3	9.7	m	m	m
22	0.1	0.0	0.0	0.0	0.6	11.3	15.0	12.5	9.4	m	m	m
23	0.1	0.0	0.0	0.0	0.7	11.1	14.9	13.0	9.1	m	m	m
24	0.1	0.0	0.0	0.0	2.2	12.4	15.0	13.3	9.0	m	m	m
25	0.1	0.0	0.0	0.0	4.1	12.6	14.0	13.2	8.8	m	m	m
26	0.1	0.0	0.0	0.0	3.9	13.0	13.9	13.0	8.7	m	m	m
27	0.1	0.0	0.0	0.0	4.0	12.3	15.2	13.4	m	m	m	m
28	0.1	0.0	0.0	0.0	4.6	12.1	16.0	12.9	m	m	m	m
29	0.0	0.0	0.0	0.0	5.5	12.6	16.2	13.3	m	m	m	m
30	0.0	0.0	0.0	0.0	5.0	10.8	15.6	13.5	m	m	m	m
31	0.0	0.0	0.0	0.0	4.5	10.0	15.6	13.0	m	m	m	m
Mean	0.1	0.0	0.0	0.0	1.3	9.6	13.3	13.3	10.7	m	m	m
Min	0.0	0.0	0.0	0.0	0.0	4.5	9.8	12.3	8.7	m	m	m
Max	0.1	0.0	0.0	0.0	5.5	15.3	16.2	15.3	12.8	m	m	m

Notes: m – missing data

Table A.1b-2. Grant Lake – GL 0.5m daily mean temperature (C), calendar year 2013.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.5	0.7	0.7	0.5	0.9	4.4	9.8	14.3	12.7	m	m	m
2	0.5	0.8	0.7	0.5	0.9	4.8	10.4	15.2	12.3	m	m	m
3	0.5	0.7	0.7	0.5	0.9	4.6	10.3	14.7	12.1	m	m	m
4	0.5	0.7	0.6	0.5	0.9	5.2	9.7	13.5	11.7	m	m	m
5	0.5	0.7	0.6	0.5	0.8	5.4	10.3	13.5	11.6	m	m	m
6	0.5	0.8	0.6	0.5	0.8	5.6	10.8	13.4	11.5	m	m	m
7	0.5	0.8	0.7	0.5	0.8	6.0	10.6	13.6	11.5	m	m	m
8	0.5	0.7	0.7	0.5	0.8	5.8	10.6	12.3	11.3	m	m	m
9	0.5	0.7	0.7	0.5	0.9	7.1	10.8	12.6	11.2	m	m	m
10	0.5	0.7	0.7	0.5	1.1	7.8	11.8	12.5	11.2	m	m	m
11	0.5	0.7	0.6	0.5	1.1	9.4	13.0	12.3	11.2	m	m	m
12	0.6	0.7	0.6	0.5	1.2	9.1	13.2	12.9	10.7	m	m	m
13	0.6	0.7	0.7	0.5	1.3	9.2	11.5	12.9	10.5	m	m	m
14	0.6	0.7	0.7	0.5	1.6	10.0	11.9	13.0	10.8	m	m	m
15	0.6	0.7	0.6	0.5	1.7	9.8	13.5	13.3	10.9	m	m	m
16	0.6	0.7	0.6	0.5	1.8	12.1	13.9	13.4	10.7	m	m	m
17	0.7	0.7	0.6	0.5	1.9	14.5	14.9	13.8	10.6	m	m	m
18	0.7	0.7	0.6	0.5	2.0	12.4	14.7	13.7	10.6	m	m	m
19	0.7	0.7	0.6	0.5	2.2	11.9	14.0	13.2	10.5	m	m	m
20	0.7	0.7	0.6	0.5	2.8	10.6	15.2	12.6	10.1	m	m	m
21	0.6	0.7	0.7	0.5	3.4	8.9	15.9	12.2	9.7	m	m	m
22	0.7	0.7	0.6	0.5	3.8	11.1	14.7	12.5	9.4	m	m	m
23	0.8	0.7	0.6	0.5	3.7	11.0	14.5	12.9	9.1	m	m	m
24	0.7	0.7	0.6	0.5	4.6	12.2	14.7	13.2	9.0	m	m	m
25	0.7	0.7	0.6	0.6	5.4	12.3	13.6	13.0	8.8	m	m	m
26	0.7	0.7	0.6	0.7	4.5	12.5	13.7	13.0	8.8	m	m	m
27	0.7	0.7	0.6	0.7	4.9	11.9	14.9	13.3	m	m	m	m
28	0.8	0.7	0.5	0.8	4.9	11.9	15.5	12.8	m	m	m	m
29	0.8	---	0.5	0.8	5.6	12.1	15.7	13.3	m	m	m	m
30	0.8	---	0.5	0.9	4.9	10.5	15.1	13.3	m	m	m	m
31	0.7	---	0.5	---	4.4	---	15.1	12.9	---	m	---	m
Mean	0.6	0.7	0.6	0.5	2.5	9.3	13.1	13.2	10.7	m	m	m
Min	0.5	0.7	0.5	0.5	0.8	4.4	9.7	12.2	8.8	m	m	m
Max	0.8	0.8	0.7	0.9	5.6	14.5	15.9	15.2	12.7	m	m	m

Notes: m – missing data

Table A.1b-3. Grant Lake – GL 1.5m daily mean temperature (C), calendar year 2013.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	2.2	2.3	2.4	2.3	2.7	4.5	9.3	13.4	12.3	m	m	m
2	2.2	2.3	2.4	2.3	2.8	4.9	9.9	14.4	12.1	m	m	m
3	2.2	2.3	2.4	2.3	2.8	4.7	9.8	14.4	11.9	m	m	m
4	2.2	2.3	2.4	2.3	2.9	5.3	9.3	13.2	11.6	m	m	m
5	2.2	2.3	2.4	2.3	3.0	5.4	9.8	13.2	11.5	m	m	m
6	2.2	2.3	2.4	2.3	3.0	5.7	10.2	13.2	11.4	m	m	m
7	2.2	2.3	2.4	2.3	3.1	6.0	10.2	13.5	11.3	m	m	m
8	2.2	2.4	2.4	2.3	3.2	5.7	10.3	12.0	11.0	m	m	m
9	2.2	2.4	2.4	2.3	3.3	6.7	10.4	12.5	11.1	m	m	m
10	2.2	2.4	2.4	2.3	3.4	7.4	11.5	12.2	11.1	m	m	m
11	2.1	2.4	2.4	2.3	3.4	8.8	11.8	12.1	11.0	m	m	m
12	2.1	2.4	2.4	2.3	3.2	8.0	11.9	12.6	10.4	m	m	m
13	2.2	2.4	2.4	2.3	2.9	8.2	10.7	12.3	10.5	m	m	m
14	2.2	2.4	2.4	2.3	3.0	9.5	11.1	12.6	10.6	m	m	m
15	2.2	2.4	2.4	2.3	3.2	8.5	12.7	12.9	10.8	m	m	m
16	2.1	2.4	2.4	2.3	3.4	11.0	13.3	13.1	10.6	m	m	m
17	2.2	2.4	2.4	2.3	3.6	10.9	14.0	13.7	10.6	m	m	m
18	2.2	2.4	2.3	2.3	3.7	10.3	12.8	13.2	10.4	m	m	m
19	2.2	2.4	2.3	2.3	4.0	11.6	12.9	12.8	10.4	m	m	m
20	2.2	2.4	2.4	2.3	4.1	9.8	14.5	12.4	10.0	m	m	m
21	2.3	2.4	2.3	2.3	4.4	8.3	14.9	12.0	9.6	m	m	m
22	2.3	2.5	2.3	2.3	4.3	10.5	13.1	12.2	9.4	m	m	m
23	2.0	2.5	2.3	2.2	4.3	10.8	13.5	12.5	9.0	m	m	m
24	2.2	2.5	2.3	2.3	4.6	11.6	13.6	12.9	8.9	m	m	m
25	2.2	2.5	2.3	2.3	4.9	11.6	12.7	12.6	8.7	m	m	m
26	2.2	2.4	2.4	2.3	4.7	11.3	12.9	12.6	8.7	m	m	m
27	2.2	2.4	2.3	2.4	5.0	10.7	14.0	12.8	m	m	m	m
28	2.2	2.4	2.4	2.5	5.2	11.0	14.3	12.4	m	m	m	m
29	2.2	---	2.3	2.6	5.6	11.4	14.5	13.2	m	m	m	m
30	2.2	---	2.4	2.6	5.1	9.6	14.1	13.0	m	m	m	m
31	2.3	---	2.3	---	4.4	---	14.1	12.5	---	m	---	m
Mean	2.2	2.4	2.4	2.3	3.8	8.7	12.2	12.8	10.6	m	m	m
Min	2.0	2.3	2.3	2.2	2.7	4.5	9.3	12.0	8.7	m	m	m
Max	2.3	2.5	2.4	2.6	5.6	11.6	14.9	14.4	12.3	m	m	m

Notes: m – missing data

Table A.1b-4. Grant Lake – GL 3.0m daily mean temperature (C), calendar year 2013.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	2.3	2.4	2.5	2.5	2.9	4.3	9.1	12.8	12.2	m	m	m
2	2.3	2.4	2.5	2.6	2.9	4.8	9.5	14.1	11.9	m	m	m
3	2.3	2.4	2.5	2.6	2.9	4.5	9.5	14.1	11.7	m	m	m
4	2.3	2.4	2.5	2.6	2.9	5.2	9.1	13.0	11.5	m	m	m
5	2.3	2.4	2.5	2.6	3.0	5.2	9.6	13.0	11.5	m	m	m
6	2.3	2.4	2.5	2.6	3.0	5.5	9.9	13.2	11.4	m	m	m
7	2.3	2.4	2.5	2.6	3.1	5.8	10.1	13.4	11.2	m	m	m
8	2.3	2.4	2.5	2.6	3.2	5.5	10.0	11.8	11.0	m	m	m
9	2.3	2.4	2.5	2.6	3.2	6.2	10.1	12.6	11.1	m	m	m
10	2.3	2.5	2.5	2.6	3.3	6.9	11.1	12.1	11.0	m	m	m
11	2.3	2.5	2.5	2.6	3.4	7.0	10.8	12.0	11.0	m	m	m
12	2.3	2.5	2.5	2.6	3.4	6.8	10.7	12.4	10.3	m	m	m
13	2.3	2.5	2.5	2.6	3.5	7.1	10.2	12.1	10.5	m	m	m
14	2.3	2.5	2.5	2.6	3.4	8.3	10.8	12.5	10.6	m	m	m
15	2.3	2.5	2.5	2.6	3.5	7.9	12.1	12.6	10.8	m	m	m
16	2.3	2.5	2.5	2.6	3.6	9.9	12.4	13.0	10.6	m	m	m
17	2.3	2.5	2.6	2.6	3.6	9.0	12.8	13.6	10.5	m	m	m
18	2.3	2.5	2.5	2.6	3.7	9.0	11.4	12.8	10.3	m	m	m
19	2.3	2.5	2.5	2.6	3.9	11.5	11.6	12.7	10.4	m	m	m
20	2.3	2.5	2.5	2.6	4.0	9.4	13.9	12.2	10.1	m	m	m
21	2.3	2.5	2.5	2.6	4.2	8.0	12.9	11.9	9.7	m	m	m
22	2.4	2.5	2.5	2.6	4.2	10.0	12.1	12.1	9.4	m	m	m
23	2.3	2.5	2.5	2.6	4.1	10.7	12.5	12.3	9.1	m	m	m
24	2.3	2.5	2.5	2.6	4.3	11.1	12.6	12.7	8.9	m	m	m
25	2.4	2.5	2.6	2.6	4.6	11.1	12.1	12.3	8.7	m	m	m
26	2.3	2.5	2.6	2.6	4.4	10.5	12.6	12.4	8.7	m	m	m
27	2.3	2.5	2.5	2.7	4.5	9.9	13.4	12.4	m	m	m	m
28	2.3	2.5	2.5	2.7	4.8	10.5	13.0	12.2	m	m	m	m
29	2.4	---	2.5	2.8	5.3	10.8	13.4	13.1	m	m	m	m
30	2.4	---	2.6	2.8	4.9	9.3	13.5	12.8	m	m	m	m
31	2.4	---	2.6	---	4.3	---	13.4	12.3	---	m	---	m
Mean	2.3	2.5	2.5	2.6	3.7	8.1	11.5	12.7	10.5	m	m	m
Min	2.3	2.4	2.5	2.5	2.9	4.3	9.1	11.8	8.7	m	m	m
Max	2.4	2.5	2.6	2.8	5.3	11.5	13.9	14.1	12.2	m	m	m

Notes: m – missing data

Table A.1b-5. Grant Lake – GL 6.0m daily mean temperature (C), calendar year 2013.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	2.6	2.7	2.9	2.9	3.1	4.3	8.3	10.7	11.6	m	m	m
2	2.6	2.7	2.9	2.9	3.1	4.6	8.6	12.4	11.4	m	m	m
3	2.6	2.7	2.9	2.9	3.1	4.3	8.9	12.0	10.9	m	m	m
4	2.6	2.8	2.9	2.9	3.2	5.1	8.6	12.2	11.1	m	m	m
5	2.6	2.8	2.9	2.9	3.2	5.1	9.2	11.8	11.3	m	m	m
6	2.6	2.7	2.9	2.9	3.2	5.4	9.1	12.9	11.3	m	m	m
7	2.6	2.7	2.9	2.9	3.2	5.7	9.3	12.1	10.8	m	m	m
8	2.6	2.8	2.9	2.9	3.3	5.2	9.1	10.7	10.6	m	m	m
9	2.6	2.8	2.9	2.9	3.3	5.7	9.3	12.5	11.0	m	m	m
10	2.6	2.8	2.9	2.9	3.4	6.2	9.4	11.5	10.7	m	m	m
11	2.6	2.8	2.9	2.9	3.4	5.9	9.2	11.6	10.8	m	m	m
12	2.6	2.8	2.9	2.9	3.4	6.1	8.8	11.9	10.1	m	m	m
13	2.7	2.8	2.9	2.9	3.5	6.2	8.9	11.6	10.5	m	m	m
14	2.7	2.8	2.9	2.9	3.5	6.3	9.6	12.0	10.6	m	m	m
15	2.7	2.8	2.9	2.9	3.5	6.8	9.8	11.5	10.6	m	m	m
16	2.7	2.8	2.9	2.9	3.6	8.0	10.2	12.5	10.4	m	m	m
17	2.7	2.8	2.9	2.9	3.6	7.6	9.6	13.1	10.3	m	m	m
18	2.7	2.8	2.9	2.9	3.7	7.5	9.6	11.8	10.1	m	m	m
19	2.7	2.8	2.9	2.9	3.9	10.4	9.9	11.9	10.3	m	m	m
20	2.7	2.8	2.9	3.0	3.9	8.6	10.1	11.7	10.0	m	m	m
21	2.6	2.8	2.9	3.0	4.0	7.4	9.8	11.6	9.7	m	m	m
22	2.7	2.8	2.9	3.0	4.0	8.8	9.7	11.6	9.4	m	m	m
23	2.7	2.8	2.9	3.0	4.1	10.3	10.1	11.9	9.1	m	m	m
24	2.7	2.8	2.9	3.0	4.1	9.8	10.0	12.0	8.8	m	m	m
25	2.7	2.8	2.9	3.0	4.2	9.7	10.2	11.6	8.7	m	m	m
26	2.7	2.8	2.9	2.9	4.3	9.2	10.8	11.9	8.7	m	m	m
27	2.7	2.8	2.9	3.0	4.4	8.7	11.1	11.4	m	m	m	m
28	2.7	2.9	2.9	3.0	4.4	9.4	10.8	11.8	m	m	m	m
29	2.7	---	2.9	3.0	4.6	8.9	11.0	12.3	m	m	m	m
30	2.7	---	2.9	3.0	4.6	8.5	10.9	11.8	m	m	m	m
31	2.7	---	2.9	---	4.2	---	11.1	11.9	---	m	---	m
Mean	2.7	2.8	2.9	2.9	3.7	7.2	9.7	11.9	10.3	m	m	m
Min	2.6	2.7	2.9	2.9	3.1	4.3	8.3	10.7	8.7	m	m	m
Max	2.7	2.9	2.9	3.0	4.6	10.4	11.1	13.1	11.6	m	m	m

Notes: m – missing data

Table A.1b-6. Grant Lake – GL 9.0m daily mean temperature (C), calendar year 2013.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	3.0	3.1	3.1	3.1	3.3	4.2	7.6	8.7	10.5	m	m	m
2	3.0	3.1	3.1	3.2	3.3	4.5	7.7	9.8	10.8	m	m	m
3	3.0	3.1	3.2	3.2	3.3	4.3	8.2	9.1	10.0	m	m	m
4	3.0	3.1	3.2	3.2	3.3	5.1	8.0	9.6	10.2	m	m	m
5	3.0	3.0	3.2	3.2	3.3	5.0	8.5	9.2	10.5	m	m	m
6	3.0	3.1	3.2	3.2	3.4	5.5	8.2	12.0	10.6	m	m	m
7	3.0	3.1	3.2	3.2	3.4	5.6	8.3	9.8	10.1	m	m	m
8	3.0	3.1	3.2	3.2	3.4	5.1	8.2	9.7	10.1	m	m	m
9	3.1	3.1	3.2	3.2	3.5	5.5	8.4	11.4	10.6	m	m	m
10	3.1	3.1	3.2	3.2	3.5	5.8	8.2	10.0	10.2	m	m	m
11	3.1	3.0	3.2	3.2	3.5	5.6	8.2	10.8	10.3	m	m	m
12	3.1	3.1	3.2	3.2	3.6	5.8	8.1	10.8	9.9	m	m	m
13	3.1	3.1	3.2	3.2	3.6	5.7	7.8	10.3	10.5	m	m	m
14	3.0	3.1	3.2	3.2	3.7	5.8	8.4	10.9	10.2	m	m	m
15	3.0	3.1	3.2	3.2	3.7	6.0	8.5	10.1	10.1	m	m	m
16	3.1	3.1	3.2	3.2	3.7	6.8	8.6	11.2	10.1	m	m	m
17	3.1	3.1	3.2	3.2	3.7	6.8	8.4	11.2	9.9	m	m	m
18	3.1	3.1	3.2	3.2	3.9	6.7	8.3	10.8	9.9	m	m	m
19	3.1	3.1	3.2	3.2	3.9	8.3	8.3	10.7	10.1	m	m	m
20	3.0	3.1	3.1	3.2	3.9	7.6	8.3	10.7	9.9	m	m	m
21	3.0	3.1	3.1	3.2	4.0	6.8	8.2	11.0	9.6	m	m	m
22	3.0	3.1	3.1	3.2	4.0	7.7	8.3	11.0	9.4	m	m	m
23	3.1	3.1	3.2	3.2	4.0	9.7	8.6	10.9	9.0	m	m	m
24	3.1	3.1	3.2	3.2	4.0	7.9	8.3	11.0	8.8	m	m	m
25	3.1	3.1	3.2	3.2	4.0	8.2	8.5	10.6	8.4	m	m	m
26	3.1	3.1	3.1	3.2	4.1	8.2	8.6	11.1	8.5	m	m	m
27	3.1	3.1	3.2	3.2	4.1	7.7	8.7	10.4	m	m	m	m
28	3.1	3.1	3.2	3.2	4.1	8.2	8.9	11.1	m	m	m	m
29	3.1	---	3.2	3.3	4.2	8.0	8.9	10.9	m	m	m	m
30	3.1	---	3.2	3.3	4.3	7.8	8.7	10.7	m	m	m	m
31	3.0	---	3.2	---	4.2	---	8.8	11.2	---	m	---	m
Mean	3.1	3.1	3.2	3.2	3.7	6.5	8.3	10.5	9.9	m	m	m
Min	3.0	3.0	3.1	3.1	3.3	4.2	7.6	8.7	8.4	m	m	m
Max	3.1	3.1	3.2	3.3	4.3	9.7	8.9	12.0	10.8	m	m	m
Notes:	**m – missing data**											

Table A.1b-7. Grant Lake – GL 12.0m daily mean temperature (C), calendar year 2013.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	3.2	3.2	3.3	3.3	3.4	4.1	7.1	7.5	8.9	m	m	m
2	3.2	3.3	3.3	3.3	3.4	4.4	7.1	8.1	9.2	m	m	m
3	3.3	3.3	3.3	3.3	3.4	4.2	7.1	7.8	8.7	m	m	m
4	3.3	3.3	3.3	3.3	3.5	5.0	7.0	7.4	8.9	m	m	m
5	3.2	3.3	3.3	3.3	3.5	4.9	7.4	7.6	8.8	m	m	m
6	3.2	3.2	3.3	3.3	3.5	5.4	7.5	8.1	9.7	m	m	m
7	3.2	3.3	3.3	3.3	3.5	5.3	7.0	8.1	9.3	m	m	m
8	3.3	3.3	3.3	3.3	3.5	4.9	7.3	8.0	9.0	m	m	m
9	3.3	3.3	3.3	3.3	3.5	5.3	7.5	9.3	10.2	m	m	m
10	3.2	3.2	3.3	3.3	3.6	5.5	7.0	8.6	9.3	m	m	m
11	3.3	3.2	3.3	3.3	3.6	5.3	7.5	8.7	9.6	m	m	m
12	3.3	3.3	3.3	3.3	3.7	5.4	7.2	8.4	9.6	m	m	m
13	3.2	3.3	3.3	3.3	3.8	5.2	6.9	8.3	10.4	m	m	m
14	3.2	3.3	3.3	3.3	3.8	5.4	7.3	8.4	9.7	m	m	m
15	3.2	3.3	3.3	3.3	3.8	5.5	7.4	8.4	9.6	m	m	m
16	3.2	3.3	3.3	3.3	3.8	6.1	7.4	8.8	9.6	m	m	m
17	3.3	3.3	3.3	3.3	3.8	6.2	7.5	8.8	9.4	m	m	m
18	3.2	3.3	3.3	3.3	3.8	6.0	7.3	9.3	9.5	m	m	m
19	3.2	3.3	3.3	3.3	3.8	7.2	7.3	8.6	9.7	m	m	m
20	3.2	3.3	3.3	3.3	3.9	6.5	7.2	8.4	9.4	m	m	m
21	3.2	3.2	3.3	3.3	3.9	6.2	7.2	9.1	9.2	m	m	m
22	3.3	3.3	3.3	3.3	3.9	6.7	7.3	8.5	9.4	m	m	m
23	3.3	3.3	3.3	3.3	3.9	8.4	7.2	9.0	9.1	m	m	m
24	3.2	3.3	3.3	3.3	3.9	6.8	7.2	8.9	8.8	m	m	m
25	3.2	3.3	3.3	3.3	3.9	6.7	7.4	8.6	8.1	m	m	m
26	3.2	3.2	3.3	3.3	3.9	7.1	7.3	8.9	8.2	m	m	m
27	3.3	3.3	3.3	3.4	3.9	6.9	7.4	8.6	m	m	m	m
28	3.3	3.3	3.3	3.4	3.9	7.1	7.5	9.0	m	m	m	m
29	3.3	---	3.3	3.4	4.0	7.1	7.6	8.9	m	m	m	m
30	3.3	---	3.3	3.4	4.2	7.0	7.3	8.8	m	m	m	m
31	3.3	---	3.3	---	4.1	---	7.3	8.8	---	m	---	m
Mean	3.3	3.3	3.3	3.3	3.7	5.9	7.3	8.5	9.3	m	m	m
Min	3.2	3.2	3.3	3.3	3.4	4.1	6.9	7.4	8.1	m	m	m
Max	3.3	3.3	3.3	3.4	4.2	8.4	7.6	9.3	10.4	m	m	m

Notes: m – missing data

Table A.1b-8. Grant Lake – GL 15.0m daily mean temperature (C), calendar year 2013.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	3.2	3.3	3.4	3.4	3.4	4.1	6.5	6.4	7.1	m	m	m
2	3.4	3.3	3.4	3.4	3.5	4.3	6.6	6.8	6.9	m	m	m
3	3.3	3.3	3.3	3.4	3.4	4.1	6.1	6.7	7.5	m	m	m
4	3.4	3.4	3.3	3.4	3.5	5.0	6.2	6.4	7.5	m	m	m
5	3.3	3.3	3.3	3.4	3.4	4.8	6.5	6.6	7.4	m	m	m
6	3.3	3.4	3.3	3.4	3.5	5.3	6.6	6.3	8.2	m	m	m
7	3.3	3.3	3.3	3.4	3.5	5.0	6.0	6.9	7.8	m	m	m
8	3.3	3.4	3.4	3.4	3.6	4.7	6.5	6.9	6.8	m	m	m
9	3.4	3.4	3.4	3.3	3.7	5.2	6.5	7.1	9.0	m	m	m
10	3.3	3.3	3.4	3.4	3.7	5.3	6.3	7.2	7.9	m	m	m
11	3.3	3.3	3.4	3.3	3.7	5.2	6.5	6.5	8.6	m	m	m
12	3.3	3.3	3.4	3.4	3.8	5.2	6.2	6.9	8.4	m	m	m
13	3.3	3.3	3.4	3.4	3.8	5.0	6.4	6.6	9.6	m	m	m
14	3.2	3.4	3.4	3.4	3.8	5.3	6.4	6.6	8.3	m	m	m
15	3.2	3.3	3.4	3.4	3.8	5.2	6.4	6.9	8.7	m	m	m
16	3.2	3.3	3.4	3.4	3.8	5.8	6.4	7.2	8.4	m	m	m
17	3.3	3.4	3.4	3.4	3.8	5.6	6.7	7.3	8.6	m	m	m
18	3.3	3.4	3.4	3.4	3.8	5.6	6.5	7.5	8.5	m	m	m
19	3.4	3.4	3.4	3.5	3.8	6.4	6.5	6.9	8.1	m	m	m
20	3.3	3.4	3.4	3.4	3.8	6.0	6.5	6.6	8.3	m	m	m
21	3.3	3.3	3.4	3.4	3.9	5.9	6.5	7.0	8.4	m	m	m
22	3.3	3.4	3.4	3.4	3.9	6.2	6.6	7.2	8.8	m	m	m
23	3.3	3.4	3.4	3.4	3.9	7.2	6.3	6.9	8.7	m	m	m
24	3.3	3.4	3.4	3.4	3.9	6.3	6.3	6.7	8.5	m	m	m
25	3.3	3.4	3.4	3.4	3.9	5.9	6.5	6.7	7.3	m	m	m
26	3.3	3.3	3.4	3.4	3.9	6.0	6.4	7.0	7.4	m	m	m
27	3.3	3.4	3.4	3.4	3.9	6.2	6.5	7.0	m	m	m	m
28	3.3	3.4	3.4	3.4	3.9	6.4	6.5	7.3	m	m	m	m
29	3.3	---	3.4	3.4	4.0	6.3	6.6	7.5	m	m	m	m
30	3.3	---	3.4	3.4	4.0	6.4	6.4	6.9	m	m	m	m
31	3.4	---	3.4	---	4.1	---	6.4	6.9	---	m	---	m
Mean	3.3	3.3	3.4	3.4	3.8	5.5	6.4	6.9	8.1	m	m	m
Min	3.2	3.3	3.3	3.3	3.4	4.1	6.0	6.3	6.8	m	m	m
Max	3.4	3.4	3.4	3.5	4.1	7.2	6.7	7.5	9.6	m	m	m
Notes:	**m – missing data**											

Table A.1b-9. Grant Lake – GL 18.0m daily mean temperature (C), calendar year 2013.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	3.2	3.3	3.4	3.4	3.4	4.1	5.8	5.7	5.8	m	m	m
2	3.3	3.3	3.4	3.4	3.4	4.3	5.9	6.0	5.6	m	m	m
3	3.3	3.3	3.4	3.4	3.4	4.1	5.6	5.8	6.6	m	m	m
4	3.3	3.3	3.4	3.4	3.5	5.0	5.6	5.7	6.1	m	m	m
5	3.3	3.3	3.3	3.4	3.5	4.7	5.7	5.9	6.4	m	m	m
6	3.3	3.4	3.3	3.4	3.5	5.3	5.7	5.5	6.5	m	m	m
7	3.3	3.4	3.3	3.4	3.6	5.0	5.4	6.0	6.2	m	m	m
8	3.3	3.4	3.4	3.4	3.7	4.7	5.9	5.9	5.5	m	m	m
9	3.3	3.3	3.4	3.3	3.8	5.2	5.8	6.2	7.5	m	m	m
10	3.3	3.3	3.4	3.3	3.7	5.3	5.8	6.3	6.7	m	m	m
11	3.3	3.3	3.4	3.3	3.7	5.1	5.7	5.5	6.8	m	m	m
12	3.3	3.3	3.4	3.3	3.8	5.2	5.4	5.9	6.8	m	m	m
13	3.3	3.3	3.4	3.4	3.7	5.0	5.9	5.8	7.7	m	m	m
14	3.2	3.3	3.4	3.4	3.7	5.1	5.8	5.7	6.9	m	m	m
15	3.2	3.3	3.5	3.4	3.7	5.1	5.8	6.0	6.2	m	m	m
16	3.3	3.3	3.5	3.5	3.8	5.5	5.7	6.1	6.6	m	m	m
17	3.3	3.3	3.4	3.5	3.8	5.3	6.0	6.2	6.4	m	m	m
18	3.3	3.3	3.4	3.4	3.8	5.2	5.7	6.2	6.5	m	m	m
19	3.3	3.3	3.4	3.4	3.8	5.9	5.7	5.9	6.5	m	m	m
20	3.3	3.3	3.4	3.4	3.8	5.5	6.0	5.5	6.8	m	m	m
21	3.3	3.3	3.4	3.4	3.9	5.5	6.0	5.9	6.9	m	m	m
22	3.3	3.4	3.4	3.4	3.9	5.8	5.8	5.9	7.0	m	m	m
23	3.3	3.4	3.4	3.4	3.9	6.4	5.6	5.9	7.2	m	m	m
24	3.3	3.4	3.3	3.4	3.9	5.8	5.8	5.8	7.1	m	m	m
25	3.3	3.4	3.4	3.4	3.9	5.3	5.9	6.1	6.3	m	m	m
26	3.3	3.4	3.4	3.4	3.9	5.3	5.7	5.9	6.9	m	m	m
27	3.3	3.4	3.4	3.4	3.9	5.7	5.7	5.9	m	m	m	m
28	3.3	3.4	3.4	3.5	3.9	5.8	5.7	6.0	m	m	m	m
29	3.3	---	3.4	3.4	4.0	5.5	5.8	6.3	m	m	m	m
30	3.3	---	3.4	3.4	4.0	5.7	5.8	5.9	m	m	m	m
31	3.3	---	3.4	---	4.2	---	5.7	5.7	---	m	---	m
Mean	3.3	3.3	3.4	3.4	3.8	5.2	5.8	5.9	6.6	m	m	m
Min	3.2	3.3	3.3	3.3	3.4	4.1	5.4	5.5	5.5	m	m	m
Max	3.3	3.4	3.5	3.5	4.2	6.4	6.0	6.3	7.7	m	m	m

Notes: m – missing data

Table A.1b-10. Grant Lake – GL 19.5m daily mean temperature (C), calendar year 2013.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	3.2	3.3	3.4	3.3	3.4	4.1	5.7	5.5	5.6	m	m	m
2	3.2	3.3	3.4	3.3	3.4	4.3	5.7	5.7	5.5	m	m	m
3	3.3	3.3	3.4	3.3	3.4	4.1	5.5	5.7	6.5	m	m	m
4	3.3	3.3	3.3	3.4	3.5	4.9	5.6	5.7	6.0	m	m	m
5	3.3	3.3	3.3	3.4	3.5	4.6	5.6	5.7	6.2	m	m	m
6	3.3	3.3	3.3	3.4	3.5	5.3	5.5	5.4	6.0	m	m	m
7	3.3	3.4	3.3	3.4	3.6	4.9	5.3	5.8	6.0	m	m	m
8	3.3	3.3	3.3	3.4	3.7	4.6	5.8	5.8	5.4	m	m	m
9	3.3	3.3	3.3	3.3	3.7	5.1	5.7	6.1	7.0	m	m	m
10	3.3	3.3	3.4	3.3	3.7	5.2	5.7	6.1	6.5	m	m	m
11	3.3	3.3	3.4	3.3	3.7	5.0	5.6	5.4	6.2	m	m	m
12	3.3	3.3	3.5	3.3	3.7	5.1	5.3	5.8	6.3	m	m	m
13	3.2	3.3	3.4	3.3	3.7	4.9	5.7	5.7	6.7	m	m	m
14	3.2	3.3	3.4	3.4	3.7	5.1	5.7	5.6	6.4	m	m	m
15	3.2	3.3	3.4	3.4	3.7	5.0	5.6	5.8	5.9	m	m	m
16	3.3	3.3	3.4	3.4	3.8	5.4	5.6	6.0	6.1	m	m	m
17	3.3	3.3	3.4	3.4	3.8	5.2	5.9	6.0	6.1	m	m	m
18	3.3	3.3	3.4	3.4	3.8	5.1	5.5	5.9	6.1	m	m	m
19	3.3	3.3	3.4	3.4	3.8	5.7	5.6	5.9	6.2	m	m	m
20	3.3	3.3	3.4	3.4	3.8	5.4	5.9	5.4	6.4	m	m	m
21	3.3	3.3	3.4	3.4	3.9	5.4	5.9	5.9	6.7	m	m	m
22	3.3	3.3	3.4	3.3	3.9	5.7	5.7	5.7	6.6	m	m	m
23	3.3	3.3	3.4	3.4	3.9	6.2	5.5	5.7	6.8	m	m	m
24	3.3	3.4	3.3	3.4	3.9	5.8	5.6	5.6	6.5	m	m	m
25	3.3	3.4	3.4	3.4	3.9	5.2	5.9	6.0	6.2	m	m	m
26	3.3	3.4	3.3	3.4	3.9	5.2	5.6	5.9	6.7	m	m	m
27	3.3	3.4	3.3	3.4	3.9	5.6	5.6	5.7	m	m	m	m
28	3.3	3.4	3.3	3.4	3.9	5.7	5.6	5.8	m	m	m	m
29	3.3	---	3.4	3.4	4.0	5.4	5.7	6.1	m	m	m	m
30	3.3	---	3.3	3.4	4.0	5.6	5.7	5.8	m	m	m	m
31	3.3	---	3.3	---	4.1	---	5.5	5.5	---	m	---	m
Mean	3.3	3.3	3.4	3.4	3.7	5.2	5.6	5.8	6.3	m	m	m
Min	3.2	3.3	3.3	3.3	3.4	4.1	5.3	5.4	5.4	m	m	m
Max	3.3	3.4	3.5	3.4	4.1	6.2	5.9	6.1	7.0	m	m	m
Notes:	**m – missing data**											

Appendix 1c. Historical Grant Creek Temperature Records – 2013

This appendix contains the following figures and tables:

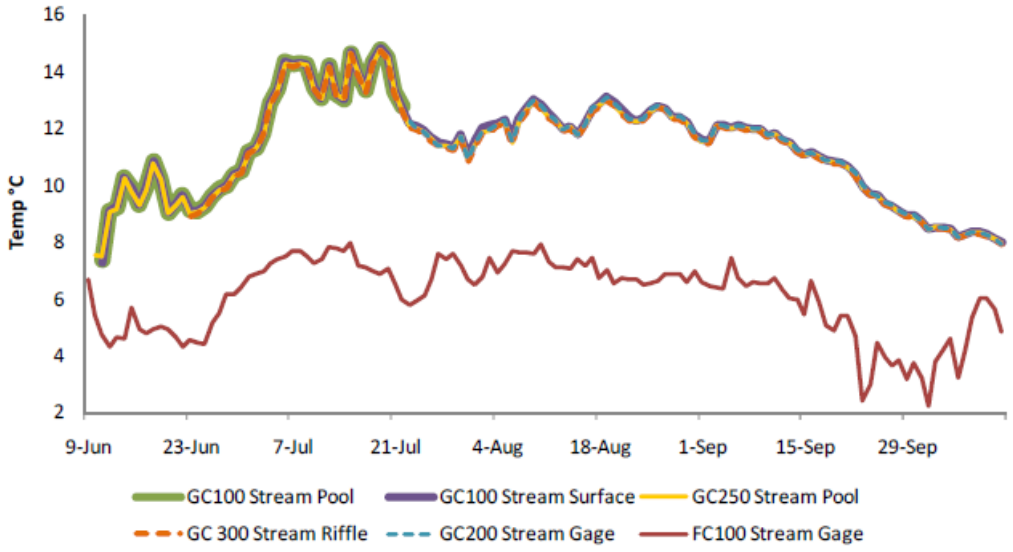


Figure A.1c-1. Grant Creek and Falls Creek – daily mean temperature (C), calendar year 2009. *(Figure reproduced from HDR 2009)*

Table A.1c-1. Grant Creek – near USGS gaging station 15246000 daily mean temperature (C), calendar year 1982. *(Table reproduced from Ebasco 1984)*

TABLE 3.1.4
WATER TEMPERATURE GRANT CREEK NEAR GAGING STATION
MEAN DAILY TEMPERATURE °C

Day	Sept	Oct	Nov
1	11.5	7.8	3.2
2	11.0	7.8	3.5
3	11.0	7.6	3.3
4	11.5	7.5	3.1
5	11.2	7.3	3.2
6	11.0	7.0	3.1
7	10.9	6.8	2.9
8	10.6	6.5	2.8
9	10.3	6.4	3.1
10	10.4	6.5	3.0
11	10.3	6.3	3.0
12	9.8	6.5	3.0
13	9.5	6.3	3.1
14	9.6	6.1	3.3
15	9.1	6.0	3.1
16	9.2	5.9	3.0
17	9.1	5.9	2.4
18	9.0	5.8	1.9
19	9.0	5.6	1.1
20	9.0	5.4	1.1
21	9.0	4.9	1.8
22	9.0	4.7	1.8
23	8.7	4.6	1.8
24	8.6	4.4	1.8
25	8.3	4.2	
26	8.2	3.8	
27	8.2	3.4	
28	8.1	3.1	
29	8.0	3.3	
30	7.9	3.2	
31	-	3.1	

Table A.1c-2. Grant Creek – near USGS gaging station 15246000 instantaneous water temperature (C), 1982-1983. *(Table reproduced from Ebasco 1984)*

TABLE 3.1.2
WATER TEMPERATURES - AT GAGING STATION
GRANT CREEK NEAR MOOSE PASS

Date	Temperature (°C)
11-24-82	1.9
01-21-83	1.8
03-23-83	2.7
05-17-83	5.5
06-16-83	8.7
07-08-83	12.5
08-05-83	13.5
09-01-83	11.5
10-03-83	7.0
11-04-83	4.4
12-07-83	3.0

Table A.1c-3. Grant Creek – GC250 daily mean temperature (C), calendar year 2009.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	m	m	m	m	m	m	m	m	m	m	5.4	2.7
2	m	m	m	m	m	m	m	m	m	m	5.1	2.7
3	m	m	m	m	m	m	m	m	m	m	5.2	2.6
4	m	m	m	m	m	m	m	m	m	m	5.3	2.3
5	m	m	m	m	m	m	m	m	m	m	5.4	1.7
6	m	m	m	m	m	m	m	m	m	m	5.3	1.7
7	m	m	m	m	m	m	m	m	m	m	5.2	1.6
8	m	m	m	m	m	m	m	m	m	m	4.9	1.8
9	m	m	m	m	m	m	m	m	m	m	4.5	1.5
10	m	m	m	m	m	m	m	m	m	m	4.4	1.2
11	m	m	m	m	m	m	m	m	m	m	4.3	1.1
12	m	m	m	m	m	m	m	m	m	8.0	4.0	1.0
13	m	m	m	m	m	m	m	m	m	7.8	3.9	1.2
14	m	m	m	m	m	m	m	m	m	7.8	3.3	1.5
15	m	m	m	m	m	m	m	m	m	7.8	2.9	1.3
16	m	m	m	m	m	m	m	m	m	7.6	2.6	1.2
17	m	m	m	m	m	m	m	m	m	7.4	2.6	0.9
18	m	m	m	m	m	m	m	m	m	7.4	2.5	0.6
19	m	m	m	m	m	m	m	m	m	7.2	2.3	0.9
20	m	m	m	m	m	m	m	m	m	7.2	2.9	1.4
21	m	m	m	m	m	m	m	m	m	7.1	3.0	1.6
22	m	m	m	m	m	m	m	m	m	7.1	3.1	1.6
23	m	m	m	m	m	m	m	m	m	7.0	2.5	1.6
24	m	m	m	m	m	m	m	m	m	6.8	3.0	1.6
25	m	m	m	m	m	m	m	m	m	6.7	2.8	1.7
26	m	m	m	m	m	m	m	m	m	6.6	2.8	1.6
27	m	m	m	m	m	m	m	m	m	6.5	2.8	1.6
28	m	m	m	m	m	m	m	m	m	6.4	2.9	1.5
29	m	---	m	m	m	m	m	m	m	5.9	2.5	1.3
30	m	---	m	m	m	m	m	m	m	5.6	2.4	1.3
31	m	---	m	---	m	---	m	m	---	5.4	---	1.5
Mean	m	m	m	m	m	m	m	m	m	7.0	3.7	1.6
Min	m	m	m	m	m	m	m	m	m	5.4	2.3	0.6
Max	m	m	m	m	m	m	m	m	m	8.0	5.4	2.7

Notes: m – missing data

Table A.1c-4. Grant Creek – GC250 daily mean temperature (C), calendar year 2010.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.9	1.4	2.4	1.7	3.4	9.6	9.4	10.7	11.1	8.8	5.1	0.8
2	0.7	1.4	2.4	2.0	3.4	9.8	10.9	10.3	11.3	8.7	5.0	1.0
3	1.3	1.4	2.3	1.8	3.6	8.6	11.2	11.0	11.1	8.5	4.8	1.0
4	1.6	0.9	2.1	1.9	3.7	9.2	10.4	10.9	10.7	8.3	4.7	1.1
5	1.6	0.9	2.2	1.7	3.7	9.6	10.0	11.9	10.9	8.0	4.7	0.9
6	1.6	1.2	2.1	1.8	3.7	9.3	9.9	11.1	10.9	7.9	4.7	1.1
7	1.7	1.3	1.7	1.5	3.8	9.2	10.5	11.2	11.8	7.7	4.6	1.3
8	1.4	1.0	1.8	1.4	3.9	8.5	10.4	11.0	11.2	7.5	4.3	1.0
9	1.6	1.4	1.9	1.4	4.0	8.6	10.1	11.5	10.6	7.4	4.3	0.7
10	1.3	1.7	1.5	1.5	3.4	8.9	10.1	10.7	9.8	7.3	4.2	0.9
11	0.7	1.8	1.3	1.7	1.8	9.6	9.9	11.7	10.1	7.2	4.4	0.9
12	0.9	1.7	1.4	1.8	3.4	9.7	9.7	11.4	10.3	6.9	4.4	0.6
13	1.2	1.7	1.7	1.8	3.8	9.2	10.5	11.8	9.4	6.7	4.3	0.6
14	1.4	1.8	1.7	1.7	3.8	8.3	10.3	12.6	9.5	6.4	4.1	0.7
15	1.3	1.9	2.0	1.7	4.0	9.0	9.9	11.9	9.8	6.4	3.8	0.5
16	1.5	2.0	1.8	1.6	4.1	8.9	10.2	11.0	9.4	6.3	3.1	0.5
17	1.5	2.1	1.5	2.0	4.3	8.4	10.1	10.6	11.7	6.3	2.9	0.4
18	1.3	2.0	1.9	2.0	4.5	8.8	10.3	12.5	11.3	6.4	3.0	0.5
19	1.1	2.1	2.0	1.9	4.7	8.9	10.8	12.2	11.3	6.2	3.1	0.7
20	1.1	2.0	2.0	1.9	5.2	9.7	10.6	11.5	10.9	6.1	3.1	0.9
21	0.7	2.1	1.9	2.1	4.9	9.9	11.1	11.7	10.9	6.0	3.0	0.6
22	0.7	2.2	2.0	2.1	4.7	10.4	11.3	11.3	10.8	6.0	3.5	0.6
23	0.5	2.4	1.9	2.3	5.6	10.6	11.6	12.6	10.7	5.8	3.3	0.5
24	0.7	2.4	1.9	2.3	5.6	10.4	10.1	11.9	10.4	5.8	3.4	0.5
25	0.6	2.2	1.8	2.6	6.1	10.7	10.2	12.0	10.2	5.8	3.4	0.7
26	0.9	1.8	1.5	2.9	7.2	11.2	10.4	11.1	9.7	5.5	2.9	0.8
27	1.2	1.7	1.7	3.0	8.3	10.4	10.8	11.1	9.1	5.4	2.8	0.9
28	1.5	2.0	1.9	3.1	8.9	10.4	10.3	11.0	8.9	5.5	2.1	0.8
29	1.4	---	2.0	3.1	9.3	9.8	9.8	11.7	9.0	5.2	1.6	0.8
30	1.1	---	2.0	3.2	9.5	10.0	10.7	11.3	8.9	5.0	1.2	1.2
31	1.2	---	1.8	---	9.7	---	11.3	10.7	---	4.9	---	1.2
Mean	1.2	1.7	1.9	2.1	5.0	9.5	10.4	11.4	10.4	6.6	3.7	0.8
Min	0.5	0.9	1.3	1.4	1.8	8.3	9.4	10.3	8.9	4.9	1.2	0.4
Max	1.7	2.4	2.4	3.2	9.7	11.2	11.6	12.6	11.8	8.8	5.1	1.3

Table A.1c-5. Grant Creek – GC250 daily mean temperature (C), calendar year 2011.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1.4	1.7	m	m	m	m	m	m	m	m	m	m
2	1.5	1.8	m	m	m	m	m	m	m	m	m	m
3	1.6	1.6	m	m	m	m	m	m	m	m	m	m
4	1.4	1.4	m	m	m	m	m	m	m	m	m	m
5	1.4	1.1	m	m	m	m	m	m	m	m	m	m
6	1.0	1.6	m	m	m	m	m	m	m	m	m	m
7	0.8	m	m	m	m	m	m	m	m	m	m	m
8	0.7	m	m	m	m	m	m	m	m	m	m	m
9	0.8	m	m	m	m	m	m	m	m	m	m	m
10	0.8	m	m	m	m	m	m	m	m	m	m	m
11	0.8	m	m	m	m	m	m	m	m	m	m	m
12	0.6	m	m	m	m	m	m	m	m	m	m	m
13	0.5	m	m	m	m	m	m	m	m	m	m	m
14	0.4	m	m	m	m	m	m	m	m	m	m	m
15	0.4	m	m	m	m	m	m	m	m	m	m	m
16	0.3	m	m	m	m	m	m	m	m	m	m	m
17	0.6	m	m	m	m	m	m	m	m	m	m	m
18	0.7	m	m	m	m	m	m	m	m	m	m	m
19	1.0	m	m	m	m	m	m	m	m	m	m	m
20	1.3	m	m	m	m	m	m	m	m	m	m	m
21	1.5	m	m	m	m	m	m	m	m	m	m	m
22	1.4	m	m	m	m	m	m	m	m	m	m	m
23	1.0	m	m	m	m	m	m	m	m	m	m	m
24	1.6	m	m	m	m	m	m	m	m	m	m	m
25	1.7	m	m	m	m	m	m	m	m	m	m	m
26	1.6	m	m	m	m	m	m	m	m	m	m	m
27	1.4	m	m	m	m	m	m	m	m	m	m	m
28	1.2	m	m	m	m	m	m	m	m	m	m	m
29	1.4	---	m	m	m	m	m	m	m	m	m	m
30	1.4	---	m	m	m	m	m	m	m	m	m	m
31	1.5	---	m	---	m	---	m	m	---	m	---	m
Mean	1.1	1.6	m	m	m	m	m	m	m	m	m	m
Min	0.3	1.1	m	m	m	m	m	m	m	m	m	m
Max	1.7	1.8	m	m	m	m	m	m	m	m	m	m

Notes: m – missing data

Table A.1c-6. Grant Creek – GC200 daily mean temperature (C), calendar year 2012.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	m	m	m	m	m	m	m	m	m	m	m	m
2	m	m	m	m	m	m	m	m	m	m	m	m
3	m	m	m	m	m	m	m	m	m	m	m	m
4	m	m	m	m	m	m	m	m	m	m	m	m
5	m	m	m	m	m	m	m	m	m	m	m	m
6	m	m	m	m	m	m	m	m	m	m	m	m
7	m	m	m	m	m	m	m	m	m	m	m	m
8	m	m	m	m	m	m	m	m	m	m	m	m
9	m	m	m	m	m	m	m	m	m	m	m	m
10	m	m	m	m	m	m	m	m	m	m	m	m
11	m	m	m	m	m	m	m	m	m	m	m	1.0
12	m	m	m	m	m	m	m	m	m	m	m	1.1
13	m	m	m	m	m	m	m	m	m	m	m	1.3
14	m	m	m	m	m	m	m	m	m	m	m	0.6
15	m	m	m	m	m	m	m	m	m	m	m	0.6
16	m	m	m	m	m	m	m	m	m	m	m	0.4
17	m	m	m	m	m	m	m	m	m	m	m	0.2
18	m	m	m	m	m	m	m	m	m	m	m	0.5
19	m	m	m	m	m	m	m	m	m	m	m	0.6
20	m	m	m	m	m	m	m	m	m	m	m	0.4
21	m	m	m	m	m	m	m	m	m	m	m	0.2
22	m	m	m	m	m	m	m	m	m	m	m	0.2
23	m	m	m	m	m	m	m	m	m	m	m	0.6
24	m	m	m	m	m	m	m	m	m	m	m	0.9
25	m	m	m	m	m	m	m	m	m	m	m	1.1
26	m	m	m	m	m	m	m	m	m	m	m	1.2
27	m	m	m	m	m	m	m	m	m	m	m	1.4
28	m	m	m	m	m	m	m	m	m	m	m	1.5
29	m	m	m	m	m	m	m	m	m	m	m	1.4
30	m	---	m	m	m	m	m	m	m	m	m	1.6
31	m	---	m	---	m	---	m	m	---	m	---	1.6
Mean	m	m	m	m	m	m	m	m	m	m	m	0.9
Min	m	m	m	m	m	m	m	m	m	m	m	0.2
Max	m	m	m	m	m	m	m	m	m	m	m	1.6

Notes: m – missing data

[This page intentionally left blank.]

Appendix 1d. Historical Grant Lake Temperature Records – 2010-2013

This appendix contains the following figures and tables:

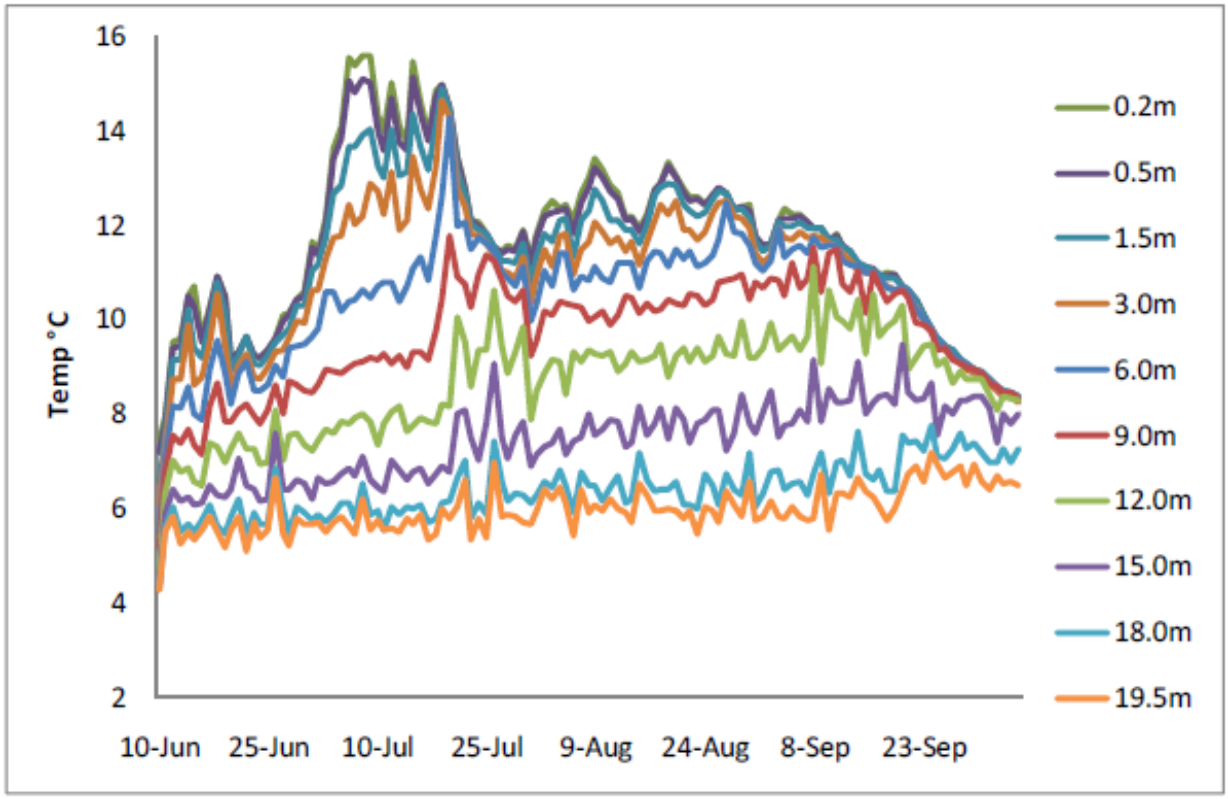


Figure A.1d-1. Grant Lake – daily mean temperature (C), calendar year 2009 *(Figure reproduced from HDR 2009)*

Table A.1d-1. Grant Lake – GL 1.5m daily mean temperature (C), calendar year 2010.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	m	m	m	m	m	m	m	m	m	8.9	5.2	2.0
2	m	m	m	m	m	m	m	m	m	8.8	5.2	2.3
3	m	m	m	m	m	m	m	m	m	8.5	5.1	1.9
4	m	m	m	m	m	m	m	m	m	8.3	5.0	2.0
5	m	m	m	m	m	m	m	m	m	8.1	4.9	2.1
6	m	m	m	m	m	m	m	m	m	8.0	4.9	2.2
7	m	m	m	m	m	m	m	m	m	7.9	4.8	2.2
8	m	m	m	m	m	m	m	m	m	7.6	4.7	2.1
9	m	m	m	m	m	m	m	m	m	7.5	4.6	2.1
10	m	m	m	m	m	m	m	m	m	7.4	4.5	2.1
11	m	m	m	m	m	m	m	m	m	7.4	4.5	2.1
12	m	m	m	m	m	m	m	m	m	7.2	4.5	2.2
13	m	m	m	m	m	m	m	m	m	7.0	4.5	2.1
14	m	m	m	m	m	m	m	m	11.6	6.8	4.4	2.1
15	m	m	m	m	m	m	m	m	11.6	6.7	4.3	2.2
16	m	m	m	m	m	m	m	m	11.7	6.6	4.2	2.2
17	m	m	m	m	m	m	m	m	11.7	6.4	3.9	2.2
18	m	m	m	m	m	m	m	m	11.6	6.4	3.1	2.2
19	m	m	m	m	m	m	m	m	11.6	6.4	3.1	2.2
20	m	m	m	m	m	m	m	m	11.3	6.3	3.2	2.3
21	m	m	m	m	m	m	m	m	11.0	6.1	3.1	2.2
22	m	m	m	m	m	m	m	m	11.0	6.1	3.4	2.2
23	m	m	m	m	m	m	m	m	10.8	6.0	3.4	2.2
24	m	m	m	m	m	m	m	m	10.7	5.9	3.1	2.2
25	m	m	m	m	m	m	m	m	10.4	5.9	3.8	2.2
26	m	m	m	m	m	m	m	m	10.1	5.8	3.9	2.2
27	m	m	m	m	m	m	m	m	9.7	5.7	2.9	2.3
28	m	m	m	m	m	m	m	m	9.3	5.6	3.2	2.2
29	m	m	m	m	m	m	m	m	9.2	5.5	3.1	2.2
30	m	m	m	m	m	m	m	m	9.1	5.4	2.6	2.3
31	m	m	m	m	m	m	m	m	8.9	5.3	2.0	2.3
Mean	m	m	m	m	m	m	m	m	10.6	6.8	4.0	2.2
Min	m	m	m	m	m	m	m	m	8.9	5.3	2.0	1.9
Max	m	m	m	m	m	m	m	m	11.7	8.9	5.2	2.3

Notes: m – missing data

Table A.1d-2. Grant Lake – GL 9.0m daily mean temperature (C), calendar year 2010.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	M	m	m	m	m	m	m	m	m	8.8	5.2	2.5
2	m	m	m	m	m	m	m	m	m	8.6	5.1	3.1
3	m	m	m	m	m	m	m	m	m	8.4	5.1	2.7
4	m	m	m	m	m	m	m	m	m	8.1	4.9	3.0
5	m	m	m	m	m	m	m	m	m	8.0	4.8	2.9
6	m	m	m	m	m	m	m	m	m	7.8	4.8	2.9
7	m	m	m	m	m	m	m	m	m	7.7	4.8	3.0
8	m	m	m	m	m	m	m	m	m	7.6	4.7	2.9
9	m	m	m	m	m	m	m	m	m	7.5	4.6	3.0
10	m	m	m	m	m	m	m	m	m	7.3	4.5	3.0
11	m	m	m	m	m	m	m	m	m	7.2	4.4	2.9
12	m	m	m	m	m	m	m	m	m	7.1	4.4	3.0
13	m	m	m	m	m	m	m	m	m	6.9	4.4	2.9
14	m	m	m	m	m	m	m	m	9.5	6.7	4.4	3.0
15	m	m	m	m	m	m	m	m	9.5	6.6	4.3	2.9
16	m	m	m	m	m	m	m	m	9.5	6.5	4.2	2.9
17	m	m	m	m	m	m	m	m	9.4	6.4	3.9	3.0
18	m	m	m	m	m	m	m	m	9.8	6.3	3.5	2.9
19	m	m	m	m	m	m	m	m	9.1	6.3	3.5	2.9
20	m	m	m	m	m	m	m	m	9.5	6.2	3.7	3.0
21	m	m	m	m	m	m	m	m	9.7	6.1	3.7	2.9
22	m	m	m	m	m	m	m	m	9.7	6.0	3.6	2.9
23	m	m	m	m	m	m	m	m	9.7	6.0	3.8	3.0
24	m	m	m	m	m	m	m	m	9.9	5.9	3.3	2.9
25	m	m	m	m	m	m	m	m	9.9	5.8	3.9	2.9
26	m	m	m	m	m	m	m	m	9.5	5.8	3.9	3.0
27	m	m	m	m	m	m	m	m	9.5	5.6	3.4	2.9
28	m	m	m	m	m	m	m	m	9.2	5.6	3.5	2.9
29	m	m	m	m	m	m	m	m	9.0	5.5	3.2	3.0
30	m	m	m	m	m	m	m	m	8.8	5.4	2.7	3.0
31	m	m	m	m	m	m	m	m	8.8	5.2	2.5	3.0
Mean	m	m	m	m	m	m	m	m	9.4	6.7	4.1	2.9
Min	m	m	m	m	m	m	m	m	8.8	5.2	2.5	2.5
Max	m	m	m	m	m	m	m	m	9.9	8.8	5.2	3.1

Notes: m – missing data

Table A.1d-3. Grant Lake – GL 18.0m daily mean temperature (C), calendar year 2010.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	m	m	m	m	m	m	m	m	m	6.9	5.1	2.8
2	m	m	m	m	m	m	m	m	m	6.6	5.0	3.4
3	m	m	m	m	m	m	m	m	m	7.8	5.0	3.1
4	m	m	m	m	m	m	m	m	m	6.6	4.9	3.3
5	m	m	m	m	m	m	m	m	m	6.6	4.8	3.3
6	m	m	m	m	m	m	m	m	m	6.4	4.7	3.2
7	m	m	m	m	m	m	m	m	m	6.8	4.7	3.3
8	m	m	m	m	m	m	m	m	m	7.1	4.6	3.3
9	m	m	m	m	m	m	m	m	m	6.1	4.5	3.2
10	m	m	m	m	m	m	m	m	m	6.7	4.4	3.2
11	m	m	m	m	m	m	m	m	m	6.6	4.4	3.3
12	m	m	m	m	m	m	m	m	m	6.7	4.4	3.3
13	m	m	m	m	m	m	m	m	m	6.1	4.4	3.3
14	m	m	m	m	m	m	m	m	6.2	6.6	4.3	3.3
15	m	m	m	m	m	m	m	m	6.1	6.5	4.2	3.3
16	m	m	m	m	m	m	m	m	5.9	6.4	4.1	3.3
17	m	m	m	m	m	m	m	m	6.0	6.0	3.9	3.3
18	m	m	m	m	m	m	m	m	6.0	6.3	3.6	3.3
19	m	m	m	m	m	m	m	m	6.2	6.0	3.6	3.3
20	m	m	m	m	m	m	m	m	5.6	5.9	3.7	3.3
21	m	m	m	m	m	m	m	m	6.1	6.0	3.8	3.3
22	m	m	m	m	m	m	m	m	6.3	6.0	3.8	3.3
23	m	m	m	m	m	m	m	m	6.6	5.9	3.9	3.3
24	m	m	m	m	m	m	m	m	5.7	5.8	3.6	3.3
25	m	m	m	m	m	m	m	m	5.7	5.7	3.9	3.2
26	m	m	m	m	m	m	m	m	6.2	5.6	3.8	3.3
27	m	m	m	m	m	m	m	m	6.2	5.6	3.5	3.3
28	m	m	m	m	m	m	m	m	6.5	5.4	3.4	3.3
29	m	m	m	m	m	m	m	m	5.7	5.4	3.2	3.3
30	m	m	m	m	m	m	m	m	7.1	5.3	3.1	3.3
31	m	m	m	m	m	m	m	m	6.9	5.2	2.8	3.3
Mean	m	m	m	m	m	m	m	m	6.2	6.2	4.1	3.3
Min	m	m	m	m	m	m	m	m	5.6	5.2	2.8	2.8
Max	m	m	m	m	m	m	m	m	7.1	7.8	5.1	3.4

Notes: m – missing data

Table A.1d-4. Grant Lake – GL 1.5m daily mean temperature (C), calendar year 2011.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	2.3	2.6	2.8	3.3	4.1	6.8	11.1	13.5	11.6	8.0	5.0	2.4
2	2.3	2.6	2.7	3.2	4.2	7.3	11.4	13.8	11.5	7.8	4.9	2.2
3	2.3	2.6	2.7	3.2	4.2	6.5	11.4	13.4	11.3	7.5	4.7	2.2
4	2.3	2.6	2.8	3.3	4.3	6.6	12.0	12.8	11.2	7.4	4.7	2.3
5	2.3	2.6	2.8	3.3	4.4	6.7	12.0	12.4	10.9	7.3	4.6	2.3
6	2.3	2.7	2.7	3.2	4.6	7.2	12.1	12.4	10.6	7.1	4.5	2.3
7	2.3	2.7	2.7	3.2	4.8	7.0	11.9	12.3	10.5	7.2	4.5	2.4
8	2.3	2.7	2.8	3.2	4.8	7.2	12.0	12.6	10.4	7.1	4.4	2.4
9	2.3	2.7	2.7	3.3	5.2	7.2	12.0	12.3	10.3	7.0	4.2	2.4
10	2.3	2.7	2.7	3.3	5.5	7.4	12.0	12.6	10.2	6.9	4.2	2.4
11	2.4	2.7	2.7	3.3	5.7	7.3	12.1	12.6	10.1	6.8	4.1	2.4
12	2.4	2.7	2.8	3.3	5.7	7.3	11.9	12.9	10.3	6.6	4.1	2.4
13	2.4	2.7	2.8	3.4	5.7	7.6	12.7	12.9	10.1	6.5	4.1	2.4
14	2.4	2.7	2.7	3.4	5.3	7.8	12.8	13.0	10.0	6.4	3.7	2.4
15	2.4	2.7	2.9	3.5	5.2	7.9	13.3	13.3	9.7	6.4	3.2	2.4
16	2.4	2.7	2.7	3.6	5.0	8.3	12.6	13.1	9.6	6.4	3.8	2.3
17	2.4	2.7	2.7	3.7	4.8	8.9	12.8	13.1	9.6	6.3	3.4	2.3
18	2.5	2.7	2.8	3.7	4.2	9.0	12.7	12.5	9.5	6.2	2.2	2.4
19	2.5	2.8	2.6	3.7	4.2	9.3	13.2	12.3	9.2	6.0	1.9	2.5
20	2.5	2.8	2.7	3.7	4.3	9.6	13.7	12.1	9.0	5.9	2.1	2.5
21	2.5	2.7	2.8	3.8	4.4	10.0	13.7	11.9	9.0	5.9	2.6	2.5
22	2.5	2.7	2.8	3.7	4.5	10.3	13.4	12.0	8.9	5.8	2.1	2.5
23	2.5	2.7	2.9	3.8	4.6	10.2	13.9	12.3	8.7	5.8	2.1	2.5
24	2.5	2.7	2.9	3.8	5.1	10.8	13.2	12.1	8.7	5.7	2.1	2.4
25	2.5	2.7	2.9	3.8	5.2	11.0	13.3	11.8	8.6	5.6	2.2	2.5
26	2.5	2.7	2.9	3.8	5.6	11.3	13.6	12.0	8.5	5.6	2.2	2.5
27	2.6	2.7	2.9	3.9	6.1	10.9	13.5	11.8	8.4	5.4	2.4	2.4
28	2.6	2.7	3.0	4.0	6.4	10.6	13.8	11.7	8.3	5.4	2.3	2.4
29	2.6	---	3.0	3.9	6.4	11.0	13.8	11.7	8.4	5.3	2.2	2.4
30	2.6	---	3.1	3.9	6.7	11.2	14.3	11.5	8.2	5.3	2.4	2.4
31	2.6	---	3.2	---	6.3	---	14.0	11.7	---	5.1	---	2.4
Mean	2.4	2.7	2.8	3.5	5.1	8.7	12.8	12.5	9.7	6.4	3.4	2.4
Min	2.3	2.6	2.6	3.2	4.1	6.5	11.1	11.5	8.2	5.1	1.9	2.2
Max	2.6	2.8	3.2	4.0	6.7	11.3	14.3	13.8	11.6	8.0	5.0	2.5

Table A.1d-5. Grant Lake – GL 9.0m daily mean temperature (C), calendar year 2011.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	2.9	3.0	3.1	3.3	3.9	6.0	9.1	10.8	11.1	7.9	5.0	3.2
2	2.9	3.0	3.1	3.2	3.9	6.1	8.5	11.4	10.7	7.7	4.8	3.2
3	2.9	3.0	3.1	3.2	3.9	5.7	9.1	12.0	11.1	7.4	4.7	3.3
4	2.9	3.0	3.1	3.3	3.9	5.9	8.9	10.6	11.0	7.3	4.6	3.3
5	2.9	3.0	3.1	3.3	3.9	6.1	8.6	11.3	10.7	7.2	4.6	3.2
6	2.9	3.0	3.1	3.3	4.0	6.3	8.8	11.0	10.3	7.1	4.5	3.2
7	2.9	3.0	3.1	3.3	4.0	6.3	8.7	11.3	10.1	7.0	4.5	3.3
8	3.0	3.0	3.1	3.3	4.0	6.4	9.1	10.6	9.7	7.0	4.4	3.3
9	2.9	3.1	3.1	3.3	4.2	6.3	10.0	11.2	9.8	6.9	4.2	3.2
10	2.9	3.0	3.1	3.3	4.3	6.4	9.3	10.6	9.5	6.8	4.1	3.3
11	2.9	3.0	3.1	3.3	4.3	6.4	9.7	11.1	9.7	6.7	4.1	3.3
12	2.9	3.0	3.1	3.3	4.3	6.4	10.1	10.6	9.9	6.6	4.1	3.3
13	3.0	3.1	3.1	3.3	4.3	6.6	9.7	10.9	9.9	6.4	4.0	3.2
14	3.0	3.1	3.1	3.4	4.4	7.0	10.2	10.8	9.3	6.4	3.9	3.3
15	3.0	3.0	3.1	3.4	4.5	7.3	9.8	10.7	9.5	6.3	3.6	3.3
16	3.0	3.1	3.1	3.5	4.5	7.2	9.7	11.0	9.5	6.3	3.8	3.3
17	2.9	3.1	3.2	3.5	4.6	7.5	9.8	11.0	9.4	6.2	3.5	3.2
18	3.0	3.1	3.2	3.6	4.1	7.3	10.3	10.8	9.3	6.1	3.3	3.2
19	3.0	3.1	3.1	3.6	4.1	7.7	10.5	11.8	9.1	6.0	2.9	3.3
20	3.0	3.1	3.1	3.6	4.2	7.6	9.9	10.9	8.8	5.9	3.0	3.2
21	3.0	3.1	3.1	3.6	4.3	7.9	10.6	11.2	8.5	5.8	3.1	3.3
22	3.0	3.1	3.1	3.7	4.3	7.6	9.9	11.3	8.4	5.8	3.1	3.3
23	3.0	3.0	3.1	3.7	4.4	8.1	9.9	10.9	8.3	5.7	3.0	3.3
24	3.0	3.1	3.1	3.7	4.7	8.2	10.5	11.2	8.3	5.7	3.3	3.3
25	3.0	3.0	3.1	3.7	4.9	8.0	10.7	11.3	8.4	5.6	3.2	3.2
26	3.0	3.0	3.1	3.8	5.3	8.6	10.4	11.7	8.1	5.5	3.2	3.3
27	3.0	3.0	3.2	3.8	5.6	7.9	10.6	11.1	8.2	5.4	3.2	3.3
28	3.0	3.1	3.2	3.8	5.0	8.7	10.7	11.2	8.1	5.3	3.2	3.3
29	3.0	---	3.2	3.8	5.2	8.6	11.1	11.0	8.2	5.3	3.2	3.3
30	3.0	---	3.2	3.8	5.7	8.4	10.4	11.0	8.0	5.2	3.2	3.3
31	3.0	---	3.2	---	5.6	---	10.4	10.7	---	5.1	---	3.3
Mean	3.0	3.0	3.1	3.5	4.5	7.2	9.8	11.1	9.4	6.3	3.8	3.3
Min	2.9	3.0	3.1	3.2	3.9	5.7	8.5	10.6	8.0	5.1	2.9	3.2
Max	3.0	3.1	3.2	3.8	5.7	8.7	11.1	12.0	11.1	7.9	5.0	3.3
Notes:	**m – missing data**											

Table A.1d-6. Grant Lake – GL 18.0m daily mean temperature (C), calendar year 2011.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	3.3	3.3	3.3	3.3	3.8	5.2	5.7	5.8	5.9	7.8	4.9	3.4
2	3.3	3.3	3.3	3.3	3.9	5.1	6.0	5.9	6.8	7.0	4.8	3.4
3	3.3	3.3	3.3	3.4	3.9	4.8	6.1	6.1	6.6	7.0	4.6	3.4
4	3.3	3.2	3.3	3.3	3.8	5.1	5.8	6.4	6.4	6.8	4.5	3.4
5	3.2	3.3	3.3	3.3	3.9	5.4	5.8	5.6	7.9	6.8	4.5	3.4
6	3.3	3.3	3.3	3.3	3.9	5.3	5.6	6.2	7.4	6.8	4.4	3.4
7	3.2	3.3	3.3	3.4	3.9	5.3	6.0	5.9	7.2	6.8	4.4	3.4
8	3.3	3.2	3.3	3.4	3.9	5.3	5.8	6.2	7.5	6.6	4.3	3.4
9	3.3	3.3	3.3	3.4	3.9	5.5	5.5	5.7	6.6	6.7	4.1	3.4
10	3.3	3.3	3.3	3.4	3.9	5.5	5.7	6.2	7.3	6.7	4.0	3.4
11	3.3	3.3	3.3	3.3	4.0	5.5	6.2	5.8	7.1	6.6	4.0	3.4
12	3.3	3.3	3.3	3.3	4.0	5.4	5.3	5.8	8.2	6.5	4.0	3.4
13	3.3	3.3	3.3	3.3	4.0	5.5	6.0	6.0	7.1	6.4	4.0	3.4
14	3.3	3.3	3.3	3.3	4.0	5.6	6.0	6.1	7.4	6.3	3.9	3.4
15	3.3	3.3	3.3	3.4	4.0	5.8	6.3	6.2	8.1	6.2	3.7	3.4
16	3.3	3.3	3.3	3.4	4.1	5.5	6.0	5.8	9.0	6.1	3.7	3.5
17	3.3	3.3	3.3	3.5	4.3	5.7	5.8	6.1	6.9	6.1	3.4	3.4
18	3.3	3.3	3.3	3.5	4.0	5.7	5.9	5.9	7.1	6.0	3.4	3.4
19	3.3	3.3	3.3	3.5	4.1	5.8	5.8	6.6	8.5	5.9	3.4	3.4
20	3.2	3.3	3.4	3.6	4.1	5.9	5.9	6.6	7.5	5.8	3.3	3.4
21	3.3	3.2	3.4	3.6	4.2	5.4	6.0	5.7	7.6	5.7	3.3	3.4
22	3.3	3.3	3.3	3.6	4.1	5.8	5.6	6.3	7.7	5.7	3.4	3.4
23	3.2	3.3	3.4	3.6	4.3	5.6	6.4	6.2	7.4	5.7	3.4	3.4
24	3.2	3.3	3.3	3.7	4.5	5.7	5.7	6.2	7.5	5.6	3.4	3.4
25	3.2	3.3	3.3	3.7	4.7	5.9	6.0	6.0	7.3	5.5	3.4	3.5
26	3.3	3.3	3.3	3.7	4.9	5.7	5.8	6.3	7.4	5.4	3.4	3.5
27	3.2	3.3	3.3	3.7	5.0	5.9	6.0	6.1	7.5	5.3	3.4	3.4
28	3.3	3.3	3.3	3.7	4.6	5.3	5.9	6.3	7.3	5.3	3.5	3.4
29	3.3	---	3.3	3.8	4.7	5.8	6.0	5.6	7.3	5.2	3.3	3.4
30	3.3	---	3.3	3.8	5.0	5.8	6.0	6.4	7.3	5.1	3.4	3.4
31	3.3	---	3.4	---	4.8	---	6.1	6.3	---	5.0	---	3.4
Mean	3.3	3.3	3.3	3.5	4.2	5.5	5.9	6.1	7.4	6.2	3.8	3.4
Min	3.2	3.2	3.3	3.3	3.8	4.8	5.3	5.6	5.9	5.0	3.3	3.4
Max	3.3	3.3	3.4	3.8	5.0	5.9	6.4	6.6	9.0	7.8	4.9	3.5

Notes: m – missing data

Table A.1d-7. Grant Lake – GL 1.5m daily mean temperature (C), calendar year 2012.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	2.4	2.2	2.2	2.1	2.6	4.9	10.3	10.3	10.6	6.9	4.4	1.9
2	2.4	2.2	2.2	2.1	2.6	5.2	10.7	10.5	10.6	6.9	4.4	1.9
3	2.3	2.3	2.2	2.1	2.7	4.7	9.2	10.5	10.2	6.9	4.4	1.9
4	2.3	2.3	2.2	2.1	2.8	5.2	9.7	10.7	9.8	6.8	4.3	2.0
5	2.3	2.3	2.2	2.1	3.0	5.4	10.9	10.4	9.7	6.8	4.3	1.9
6	2.3	2.3	2.2	2.1	2.9	6.8	10.5	10.5	9.8	6.8	4.2	1.8
7	2.3	2.3	2.2	2.1	3.0	6.4	10.0	10.7	9.7	6.7	4.0	2.0
8	2.3	2.3	2.2	2.1	3.0	6.7	9.7	10.5	9.7	6.8	3.6	2.0
9	2.3	2.3	2.2	2.1	3.0	7.2	9.7	10.7	9.4	6.8	4.0	2.0
10	2.3	2.3	2.1	2.1	3.0	6.9	9.6	10.5	9.5	7.0	4.0	1.9
11	2.2	2.3	2.2	2.1	2.9	7.4	8.8	10.6	9.3	6.9	4.0	2.0
12	2.3	2.2	2.2	2.2	3.0	7.3	9.0	11.0	9.3	6.7	3.9	2.0
13	2.3	2.3	2.1	2.2	3.2	7.1	8.9	10.9	9.3	6.6	3.8	2.0
14	2.2	2.3	2.1	2.1	3.4	7.2	9.1	11.5	9.1	6.5	3.9	2.1
15	2.3	2.2	2.1	2.1	3.4	7.4	8.5	11.6	9.0	6.4	3.8	2.1
16	2.3	2.2	2.2	2.2	3.5	7.7	9.0	12.5	8.9	6.3	3.9	2.0
17	2.2	2.3	2.1	2.3	3.7	7.5	9.4	11.8	8.7	6.2	3.6	2.0
18	2.2	2.2	2.1	2.4	3.8	7.6	10.1	12.3	8.4	6.0	2.6	2.1
19	2.2	2.3	2.1	2.4	3.9	7.7	10.6	11.1	8.3	5.9	3.2	2.1
20	2.2	2.3	2.1	2.5	3.5	7.9	10.7	11.3	8.3	5.7	2.1	2.1
21	2.2	2.2	2.2	2.6	3.3	9.1	10.7	11.4	8.2	5.6	2.2	2.0
22	2.2	2.2	2.1	2.7	3.5	9.5	10.9	11.2	8.2	5.5	2.0	2.1
23	2.2	2.2	2.1	2.7	3.9	10.0	10.0	11.1	8.2	5.3	1.7	2.1
24	2.2	2.2	2.1	2.7	4.3	9.7	9.8	11.5	8.1	5.2	1.5	2.1
25	2.3	2.2	2.1	2.8	4.0	10.7	10.2	11.4	7.8	5.1	1.6	2.1
26	2.2	2.2	2.1	2.8	4.1	10.6	10.4	11.3	7.7	5.0	2.0	2.1
27	2.2	2.2	2.1	2.9	4.4	10.0	10.7	10.9	7.4	4.8	1.8	2.1
28	2.3	2.2	2.1	2.8	4.3	10.3	11.3	11.2	7.3	4.8	1.8	2.1
29	2.3	2.2	2.1	2.7	4.5	10.5	10.1	11.4	7.2	4.7	1.6	2.2
30	2.3	---	2.1	2.7	4.6	9.8	10.9	10.8	7.1	4.6	1.7	2.2
31	2.2	---	2.1	---	4.6	---	11.2	10.6	---	4.5	---	2.2
Mean	2.3	2.2	2.1	2.4	3.5	7.8	10.0	11.1	8.8	6.0	3.1	2.0
Min	2.2	2.2	2.1	2.1	2.6	4.7	8.5	10.3	7.1	4.5	1.5	1.8
Max	2.4	2.3	2.2	2.9	4.6	10.7	11.3	12.5	10.6	7.0	4.4	2.2

Table A.1d-8. Grant Lake – GL 9.0m daily mean temperature (C), calendar year 2012

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	3.3	3.3	3.3	3.3	3.4	4.7	7.8	8.8	9.4	6.8	4.4	3.0
2	3.3	3.3	3.3	3.3	3.4	4.8	7.8	8.2	9.6	6.8	4.3	2.9
3	3.3	3.3	3.3	3.3	3.4	4.6	7.4	8.7	9.8	6.8	4.3	3.0
4	3.3	3.3	3.3	3.3	3.4	4.7	8.7	8.6	9.4	6.8	4.3	2.9
5	3.3	3.3	3.3	3.3	3.4	4.7	10.3	8.9	8.9	6.7	4.2	3.1
6	3.3	3.3	3.3	3.3	3.4	5.4	9.2	9.8	9.4	6.5	4.2	3.1
7	3.3	3.3	3.3	3.3	3.5	5.4	9.6	9.9	9.0	6.6	4.0	3.1
8	3.3	3.3	3.3	3.3	3.5	6.1	9.1	9.0	9.0	6.7	3.7	3.0
9	3.3	3.3	3.3	3.3	3.5	5.8	9.3	8.6	9.1	6.7	3.9	3.0
10	3.3	3.3	3.3	3.3	3.5	6.5	8.5	9.1	9.1	6.8	4.0	3.0
11	3.3	3.3	3.3	3.3	3.5	7.1	8.4	8.9	8.9	6.8	4.0	3.0
12	3.3	3.3	3.3	3.3	3.5	6.4	8.7	8.6	9.2	6.6	3.9	2.9
13	3.3	3.3	3.3	3.3	3.5	6.1	8.6	9.0	8.4	6.5	3.8	3.0
14	3.3	3.3	3.3	3.3	3.5	6.8	8.3	8.8	8.8	6.4	3.9	3.0
15	3.3	3.3	3.3	3.3	3.5	7.2	8.1	9.2	8.8	6.4	3.8	3.0
16	3.3	3.3	3.3	3.3	3.5	6.8	8.4	8.4	8.7	6.3	3.8	3.0
17	3.3	3.3	3.3	3.3	3.5	6.2	8.4	8.9	8.3	6.2	3.7	3.1
18	3.3	3.3	3.3	3.4	3.6	6.2	8.2	8.7	8.2	6.0	3.3	3.0
19	3.3	3.3	3.3	3.3	3.6	6.3	8.3	9.1	8.2	5.8	3.5	2.9
20	3.3	3.3	3.3	3.4	3.6	6.6	8.2	9.5	8.1	5.7	3.3	3.0
21	3.3	3.3	3.3	3.4	3.5	7.4	8.4	9.1	7.8	5.5	3.2	3.0
22	3.3	3.3	3.3	3.4	3.6	7.3	8.1	9.1	8.1	5.4	3.1	3.0
23	3.3	3.3	3.3	3.4	3.6	7.2	8.6	10.1	8.0	5.3	3.1	3.0
24	3.3	3.3	3.3	3.4	3.8	7.6	8.4	9.0	7.7	5.1	2.8	3.0
25	3.3	3.3	3.3	3.4	3.8	7.9	8.3	9.4	7.7	5.0	2.8	3.0
26	3.3	3.3	3.3	3.4	3.9	7.7	8.2	9.2	7.6	4.9	2.9	2.9
27	3.3	3.3	3.3	3.4	4.3	7.9	8.5	9.8	7.4	4.8	2.9	3.0
28	3.3	3.3	3.3	3.4	4.1	7.5	8.2	9.0	7.2	4.7	3.1	3.0
29	3.3	3.3	3.3	3.4	4.4	7.6	8.1	9.2	7.0	4.6	2.9	3.0
30	3.3	---	3.3	3.4	4.5	7.0	8.4	9.4	6.9	4.6	3.2	3.0
31	3.3	---	3.3	---	4.5	---	8.4	9.9	---	4.5	---	3.0
Mean	3.3	3.3	3.3	3.3	3.7	6.4	8.5	9.1	8.5	5.9	3.6	3.0
Min	3.3	3.3	3.3	3.3	3.4	4.6	7.4	8.2	6.9	4.5	2.8	2.9
Max	3.3	3.3	3.3	3.4	4.5	7.9	10.3	10.1	9.8	6.8	4.4	3.1

Notes: m – missing data

Table A.1d-9. Grant Lake – GL 18.0m daily mean temperature (C), calendar year 2012.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	3.4	3.4	3.5	3.4	3.5	4.5	6.5	7.2	7.4	6.7	4.3	3.4
2	3.4	3.4	3.4	3.4	3.5	4.6	6.0	6.8	8.0	6.7	4.2	3.3
3	3.4	3.4	3.4	3.4	3.5	4.4	5.9	7.1	8.1	6.7	4.2	3.3
4	3.4	3.5	3.5	3.4	3.5	4.4	6.4	7.3	8.2	6.7	4.2	3.2
5	3.4	3.4	3.5	3.4	3.5	4.6	6.3	7.8	7.9	6.6	4.1	3.2
6	3.4	3.4	3.5	3.4	3.5	4.9	6.6	6.9	8.1	6.3	4.0	3.2
7	3.4	3.4	3.5	3.5	3.5	4.9	6.5	7.0	7.4	6.5	3.9	3.2
8	3.4	3.4	3.4	3.4	3.5	5.5	7.2	7.0	8.0	6.5	3.6	3.2
9	3.4	3.4	3.4	3.4	3.5	4.9	6.9	7.2	8.1	6.6	3.8	3.3
10	3.5	3.5	3.4	3.4	3.5	6.0	5.9	7.4	7.9	6.6	3.9	3.3
11	3.5	3.4	3.4	3.4	3.5	6.1	7.4	7.3	8.0	6.6	3.9	3.3
12	3.5	3.4	3.4	3.4	3.5	5.1	6.7	7.3	8.4	6.4	3.8	3.3
13	3.5	3.4	3.4	3.4	3.6	5.6	7.8	6.7	7.7	6.4	3.6	3.3
14	3.4	3.4	3.4	3.4	3.6	6.1	7.1	7.2	8.3	6.4	3.8	3.3
15	3.4	3.5	3.4	3.4	3.6	6.9	7.6	7.0	7.8	6.3	3.7	3.2
16	3.4	3.5	3.4	3.4	3.5	5.4	7.3	7.2	8.2	6.2	3.8	3.3
17	3.4	3.5	3.4	3.4	3.5	5.6	7.4	7.3	7.5	6.1	3.7	3.3
18	3.4	3.5	3.4	3.4	3.5	5.5	7.4	7.4	7.8	5.9	3.3	3.3
19	3.4	3.5	3.4	3.4	3.6	5.5	7.1	7.1	8.0	5.8	3.4	3.2
20	3.4	3.4	3.4	3.4	3.6	5.8	7.1	6.9	7.8	5.6	3.5	3.3
21	3.4	3.4	3.5	3.5	3.6	5.9	7.3	7.4	7.7	5.5	3.4	3.2
22	3.4	3.4	3.5	3.4	3.6	5.9	6.8	6.9	8.0	5.3	3.2	3.2
23	3.4	3.4	3.5	3.4	3.6	5.9	7.3	7.3	7.7	5.2	3.2	3.3
24	3.4	3.4	3.4	3.5	3.6	6.2	7.4	7.3	7.3	5.1	3.1	3.3
25	3.4	3.4	3.4	3.5	3.6	5.9	7.3	7.4	7.5	4.9	3.3	3.2
26	3.4	3.4	3.4	3.5	3.9	5.9	7.1	7.1	7.4	4.8	3.3	3.2
27	3.4	3.4	3.4	3.5	4.1	6.0	7.0	7.4	7.3	4.7	3.1	3.2
28	3.4	3.4	3.4	3.5	4.1	6.0	7.1	7.2	7.1	4.6	3.3	3.2
29	3.4	3.4	3.4	3.5	4.3	6.0	6.9	7.4	6.8	4.6	3.3	3.2
30	3.4	---	3.4	3.5	4.4	5.6	7.1	7.8	6.8	4.5	3.3	3.1
31	3.4	---	3.4	---	4.4	---	7.0	8.0	---	4.4	---	3.2
Mean	3.4	3.4	3.4	3.4	3.7	5.5	7.0	7.2	7.7	5.8	3.7	3.2
Min	3.4	3.4	3.4	3.4	3.5	4.4	5.9	6.7	6.8	4.4	3.1	3.1
Max	3.5	3.5	3.5	3.5	4.4	6.9	7.8	8.0	8.4	6.7	4.3	3.4

Notes: m – missing data

Appendix 2: Grant Creek Discharge Records

Appendix 2a. Grant Creek Discharge Records - 2013

Appendix 2b. Grant Historical Discharge Records – 1948-1958; 1982-1983; 2013

Appendix 2a. Grant Creek Discharge Records – 2013

This appendix contains the following figures and tables:

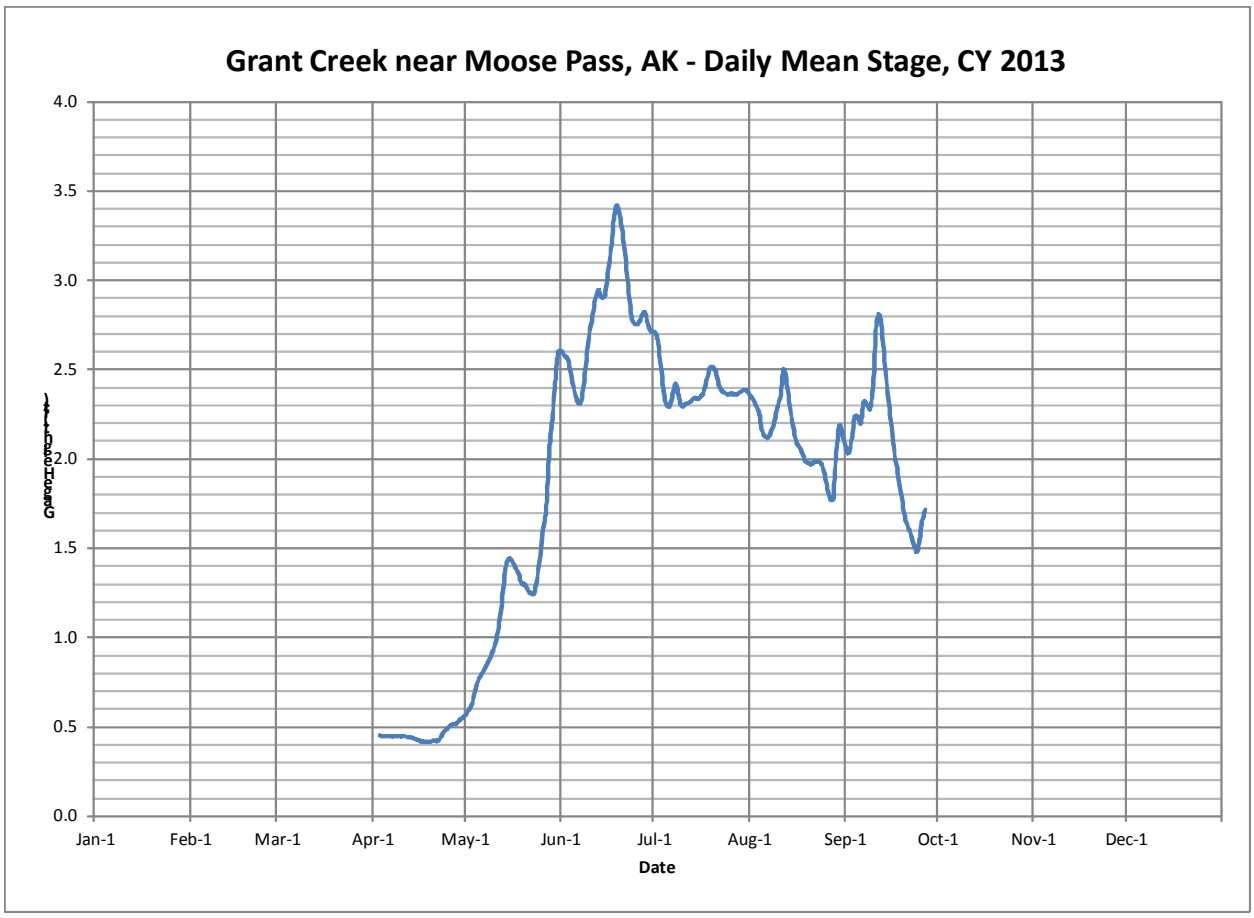


Figure A.2a-1. Grant Creek – daily mean stage (feet), calendar year 2013.

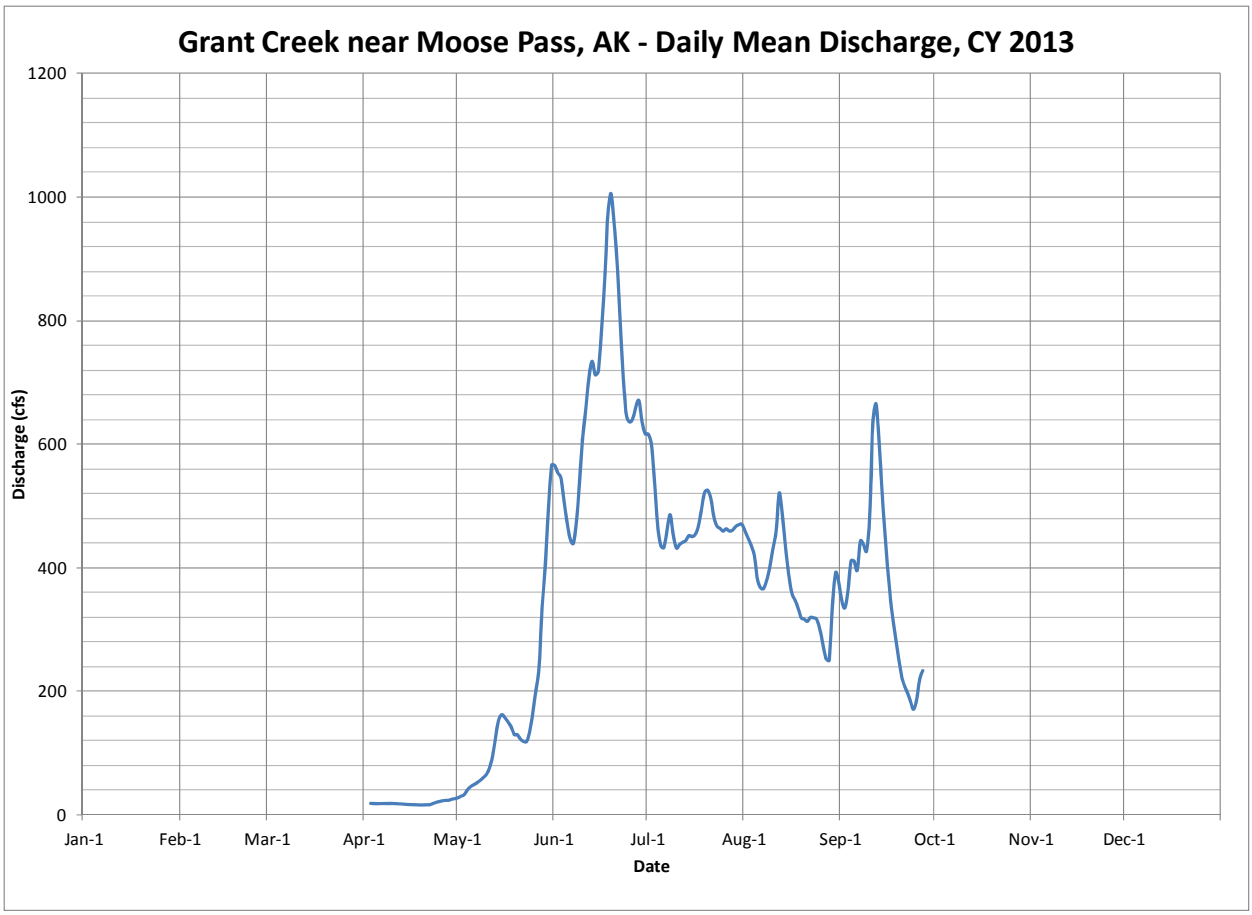


Figure A.2a-2. Grant Creek – daily mean discharge (cfs), calendar year 2013.

Table A.2a-1. Grant Creek – daily mean discharge (cfs), calendar year 2013.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	m	m	m	m	28.1	565	616	459	348	m	m	m
2	m	m	m	m	30.6	554	600	448	335	m	m	m
3	m	m	m	19.0	33.3	545	539	436	362	m	m	m
4	m	m	m	18.7	40.8	507	468	420	411	m	m	m
5	m	m	m	18.6	46.1	472	436	381	411	m	m	m
6	m	m	m	18.6	48.9	446	433	368	396	m	m	m
7	m	m	m	18.8	52.1	440	460	367	443	m	m	m
8	m	m	m	18.6	55.9	477	486	381	438	m	m	m
9	m	m	m	18.8	60.4	542	453	402	427	m	m	m
10	m	m	m	18.9	65.1	613	432	432	483	m	m	m
11	m	m	m	18.6	75.2	659	438	459	636	m	m	m
12	m	m	m	18.3	93.6	710	441	521	665	m	m	m
13	m	m	m	18.1	125	734	444	484	604	m	m	m
14	m	m	m	17.7	154	712	452	434	520	m	m	m
15	m	m	m	17.3	162	718	451	390	445	m	m	m
16	m	m	m	16.9	158	784	454	359	386	m	m	m
17	m	m	m	16.5	151	862	466	348	333	m	m	m
18	m	m	m	16.6	143	970	493	336	298	m	m	m
19	m	m	m	16.3	130	1005	521	319	264	m	m	m
20	m	m	m	16.8	130	960	526	317	230	m	m	m
21	m	m	m	16.8	123	894	514	313	211	m	m	m
22	m	m	m	17.0	119	797	483	320	200	m	m	m
23	m	m	m	18.9	119	706	468	319	185	m	m	m
24	m	m	m	20.8	135	646	464	317	171	m	m	m
25	m	m	m	21.9	167	636	459	301	185	m	m	m
26	m	m	m	23.2	203	641	463	276	219	m	m	m
27	m	m	m	23.9	240	660	459	253	234	m	m	m
28	m	m	m	24.1	340	670	461	251	m	m	m	m
29	m	---	m	25.7	404	636	467	335	m	m	m	m
30	m	---	m	26.7	499	617	470	391	m	m	m	m
31	m	---	m	---	566	---	470	378	---	m	---	m
Mean	m	m	m	19.4	152	673	477	371	364	m	m	m
Min	m	m	m	16.3	28.1	440	432	251	171	m	m	m
Max	m	m	m	26.7	566	1005	616	521	665	m	m	m

Notes: m – missing data

[This page intentionally left blank.]

Appendix 2b. Grant Historical Discharge Records – 1948-1958; 1982-1983;

This appendix contains the following figures and tables:

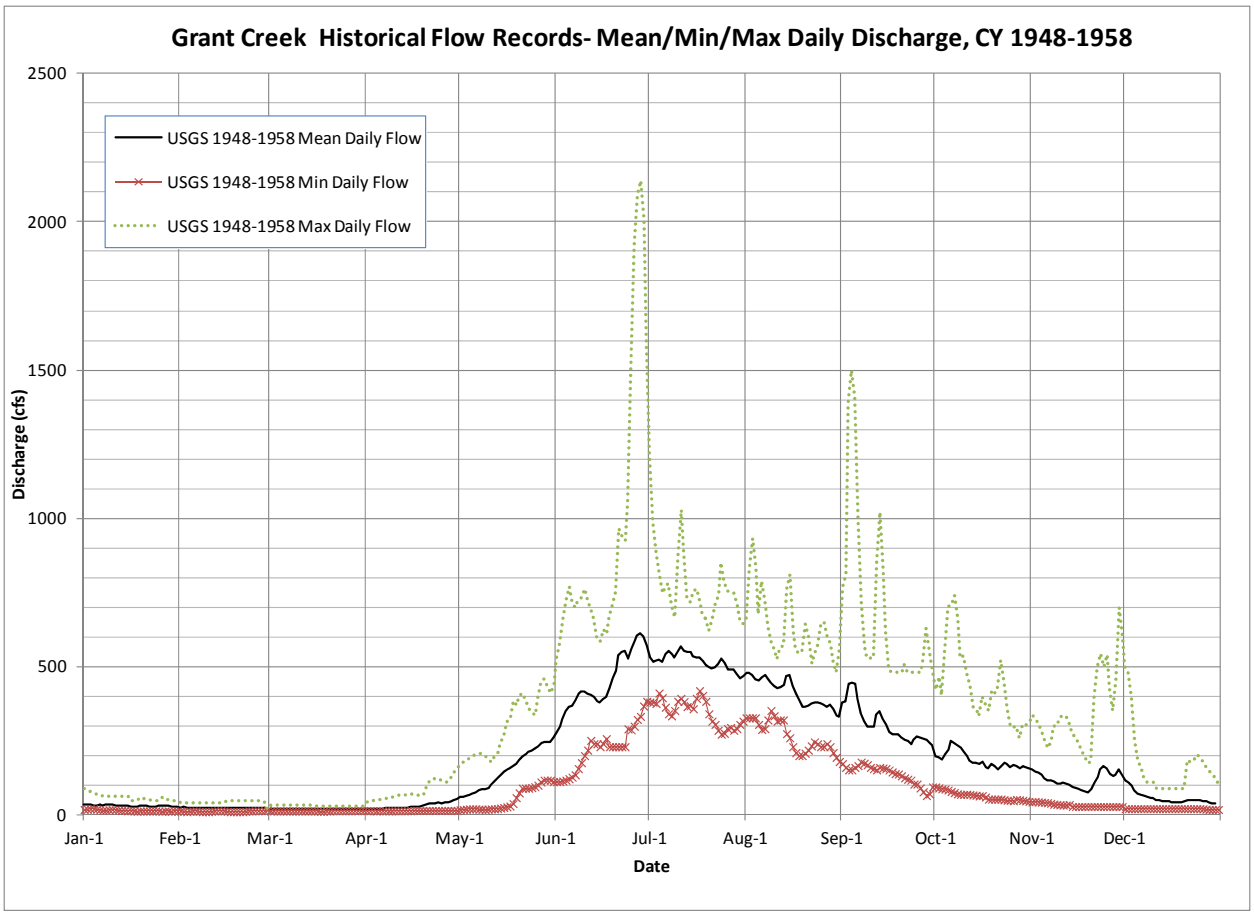


Figure A.2b-1. Grant Creek – daily mean/min/max discharge (cfs), calendar years 1948-1958. *(data reproduced from USGS website: http://waterdata.usgs.gov/ak/nwis/uv/?site_no=%2015246000&PARAmeter_cd=00065,00060)*

Table A.2b-1. Grant Creek – mean of daily mean discharge (cfs), calendar years 1948-1958.
(data reproduced from USGS website:
http://waterdata.usgs.gov/ak/nwis/uv/?site_no=%2015246000&PARAmeter_cd=00065,00060)

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	34.0	25.0	21.0	21.0	59.0	278	529	480	377	198	153	117
2	33.0	26.0	21.0	21.0	62.0	298	515	480	383	192	145	108
3	33.0	25.0	21.0	21.0	64.0	322	520	473	441	186	141	98.0
4	32.0	25.0	21.0	21.0	68.0	349	522	456	447	205	134	81.0
5	32.0	24.0	21.0	21.0	71.0	363	516	452	440	218	124	73.0
6	33.0	24.0	20.0	21.0	76.0	368	540	465	389	248	117	69.0
7	32.0	24.0	20.0	22.0	81.0	385	551	471	343	242	115	63.0
8	33.0	23.0	20.0	22.0	86.0	409	541	460	316	235	114	59.0
9	33.0	23.0	20.0	22.0	88.0	417	532	447	298	228	105	57.0
10	33.0	23.0	20.0	23.0	92	417	549	436	296	212	106	56.0
11	32.0	23.0	20.0	23.0	103	410	566	426	296	198	107	51.0
12	32.0	24.0	20.0	24.0	111	405	554	429	338	184	104	49.0
13	32.0	23.0	20.0	24.0	125	396	548	439	349	177	101	47.0
14	32.0	23.0	20.0	25.0	135	384	548	466	324	174	94.0	46.0
15	31.0	23.0	20.0	26.0	144	377	533	470	304	173	90.0	44.0
16	29.0	23.0	19.0	27.0	153	389	530	434	280	178	85.0	43.0
17	29.0	23.0	19.0	28.0	157	397	530	410	271	160	83.0	42.0
18	29.0	23.0	19.0	29.0	165	426	518	385	272	158	80.0	42.0
19	31.0	23.0	19.0	32.0	172	460	506	364	270	170	76.0	42.0
20	30.0	23.0	19.0	35.0	185	488	496	364	260	165	86.0	44.0
21	30.0	23.0	19.0	38.0	196	539	492	369	254	154	107	51.0
22	29.0	23.0	19.0	38.0	205	549	497	375	250	165	127	49.0
23	29.0	23.0	19.0	39.0	211	554	507	378	239	176	154	50.0
24	29.0	23.0	19.0	41.0	217	527	526	378	252	170	165	51.0
25	30.0	23.0	19.0	40.0	222	562	513	376	264	162	158	48.0
26	31.0	23.0	19.0	41.0	230	587	490	370	262	167	140	46.0
27	31.0	22.0	19.0	42.0	241	604	490	363	257	164	130	44.0
28	30.0	22.0	19.0	46.0	245	611	490	370	253	157	136	42.0
29	29.0	18.0	19.0	51.0	244	602	475	358	243	164	152	40.0
30	28.0	---	19.0	55.0	246	571	459	336	233	160	134	39.0
31	28.0	---	19.0	---	259	---	468	329	---	156	---	39.0
Mean	30.9	23.2	19.6	30.6	152	448	518	413	307	184	119	55.8
Min	28.0	18.0	19.0	21.0	59.0	278	459	329	233	154	76.0	39.0
Max	34.0	26.0	21.0	55.0	259	611	566	480	447	248	165	117.0

Figure A.2b-2. Grant Creek – minimum of daily mean discharge (cfs), calendar years 1948-1958. *(data reproduced from USGS website: http://waterdata.usgs.gov/ak/nwis/uv/?site_no=%2015246000&PARAmeter_cd=00065,00060)*

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	18.0	13.0	13.0	14.0	17.0	112	380	327	173	94.0	44.0	21.0
2	19.0	12.0	13.0	14.0	18.0	112	380	327	160	91.0	45.0	21.0
3	20.0	11.0	13.0	14.0	19.0	114	376	327	152	88.0	44.0	21.0
4	20.0	12.0	13.0	13.0	20.0	117	411	327	152	87.0	43.0	21.0
5	19.0	13.0	13.0	14.0	20.0	122	395	305	160	84.0	42.0	21.0
6	17.0	13.0	13.0	14.0	20.0	127	363	288	166	79.0	41.0	21.0
7	16.0	12.0	13.0	14.0	19.0	135	341	291	178	75.0	39.0	21.0
8	16.0	11.0	13.0	13.0	19.0	156	334	320	174	71.0	36.0	21.0
9	17.0	11.0	13.0	13.0	18.0	176	352	352	169	69.0	35.0	21.0
10	18.0	11.0	13.0	14.0	19.0	200	383	334	160	69.0	34.0	21.0
11	17.0	12.0	13.0	14.0	20.0	218	393	316	156	70.0	33.0	21.0
12	16.0	13.0	13.0	14.0	20.0	251	382	320	152	69.0	33.0	21.0
13	15.0	14.0	13.0	14.0	21.0	240	365	320	160	67.0	35.0	21.0
14	15.0	14.0	13.0	14.0	23.0	240	368	274	158	66.0	28.0	21.0
15	14.0	13.0	13.0	14.0	25.0	230	358	260	156	64.0	28.0	21.0
16	14.0	12.0	13.0	15.0	27.0	240	393	230	151	65.0	28.0	21.0
17	13.0	11.0	12.0	15.0	30.0	257	419	210	145	60.0	28.0	21.0
18	12.0	11.0	12.0	15.0	38.0	230	403	200	139	53.0	28.0	21.0
19	13.0	11.0	13.0	15.0	58.0	230	383	200	138	53.0	28.0	21.0
20	13.0	11.0	13.0	15.0	74.0	230	341	208	132	53.0	28.0	21.0
21	13.0	11.0	14.0	15.0	90.0	230	316	218	125	53.0	28.0	21.0
22	13.0	12.0	14.0	15.0	90.0	230	305	233	120	53.0	28.0	21.0
23	13.0	13.0	14.0	15.0	90.0	230	285	246	117	51.0	28.0	21.0
24	14.0	13.0	14.0	15.0	92.0	290	272	240	104	49.0	28.0	21.0
25	13.0	14.0	14.0	15.0	95.0	287	275	230	104	49.0	28.0	21.0
26	12.0	14.0	14.0	15.0	100	299	291	230	91.0	48.0	28.0	20.0
27	13.0	14.0	14.0	15.0	111	322	295	240	78.0	52.0	28.0	19.0
28	13.0	14.0	14.0	15.0	117	332	285	230	65.0	51.0	28.0	18.0
29	12.0	17.0	14.0	15.0	117	367	291	210	71.0	49.0	28.0	18.0
30	13.0	---	15.0	15.0	117	383	305	194	94.0	47.0	28.0	18.0
31	13.0	---	15.0	---	112	---	316	180	---	45.0	---	18.0
Mean	15.0	12.5	13.4	14.4	53.4	224	347	264	137	63.7	32.7	20.5
Min	12.0	11.0	12.0	13.0	17.0	112	272	180	65.0	45.0	28.0	18.0
Max	20.0	17.0	15.0	15.0	117	383	419	352	178	94.0	45.0	21.0

Table A.2b-3. Grant Creek – maximum of daily mean discharge (cfs), calendar years 1948-1958.
(data reproduced from USGS website:
http://waterdata.usgs.gov/ak/nwis/uv/?site_no=%2015246000&PARAmeter_cd=00065,00060)

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	90.0	42.0	33.0	44.0	170	524	1210	657	768	420	338	500
2	83.0	42.0	33.0	48.0	177	575	989	831	810	467	327	480
3	76.0	42.0	33.0	49.0	182	657	885	933	1390	404	309	400
4	72.0	42.0	33.0	50.0	193	726	810	831	1500	560	285	250
5	70.0	42.0	33.0	50.0	201	768	747	675	1410	702	253	180
6	70.0	42.0	33.0	52.0	204	726	765	789	1000	708	225	160
7	64.0	42.0	33.0	55.0	207	699	780	726	712	740	247	130
8	64.0	42.0	33.0	59.0	207	726	705	633	564	657	300	110
9	64.0	42.0	33.0	60.0	201	733	665	580	530	528	300	110
10	64.0	42.0	33.0	62.0	190	761	877	555	530	537	328	110
11	64.0	42.0	33.0	65.0	177	719	1030	526	530	478	338	90.0
12	64.0	42.0	33.0	66.0	198	699	893	565	853	436	328	90.0
13	64.0	42.0	33.0	67.0	212	663	733	570	1020	363	303	90.0
14	64.0	42.0	33.0	69.0	243	597	719	761	817	356	273	90.0
15	64.0	42.0	33.0	68.0	264	585	754	810	621	331	263	90.0
16	47.0	48.0	28.0	68.0	313	625	761	616	488	400	241	90.0
17	47.0	48.0	28.0	67.0	320	609	719	560	480	372	213	90.0
18	47.0	48.0	28.0	67.0	383	665	675	545	480	352	193	90.0
19	58.0	48.0	28.0	66.0	369	705	663	555	480	423	175	90.0
20	56.0	48.0	28.0	90.0	399	750	621	645	480	411	180	90.0
21	53.0	48.0	28.0	110	411	965	657	599	505	427	397	186
22	51.0	48.0	28.0	120	387	941	712	510	480	520	500	178
23	49.0	48.0	28.0	120	359	925	740	540	480	448	545	186
24	47.0	48.0	28.0	120	345	1050	849	569	480	356	500	202
25	47.0	48.0	28.0	115	338	1510	785	640	480	295	540	196
26	58.0	46.0	28.0	110	390	1920	754	650	480	295	430	180
27	58.0	45.0	28.0	109	446	2090	754	600	520	299	350	161
28	52.0	44.0	28.0	126	460	2140	747	575	630	260	460	147
29	47.0	19.0	28.0	145	432	2010	705	520	550	306	700	135
30	47.0	---	28.0	160	410	1610	663	480	480	302	600	122
31	47.0	---	29.0	---	439	---	645	560	---	309	---	122
Mean	59.6	43.6	30.5	81.9	298	956	775	632	685	434	348	166
Min	47.0	19.0	28.0	44.0	170	524	621	480	480	260	175	90.0
Max	90.0	48.0	33.0	160	460	2140	1210	933	1500	740	700	500
Notes:	**m – missing data**											

Table A.2b-4. Grant Creek – daily mean discharge (cfs), water year 1981-1982. *(reproduced from Ebasco 1984)*

TABLE 3.1.1
GRANT CREEK NEAR MOOSE PASS
MEAN DAILY DISCHARGE (C.F.S.)
Water Year October 1981 to September 1982

	Oct. 1981		Nov. 1981		Dec. 1981		Jan. 1982		Feb. 1982		Mar. 1982	
	GH	Q	GH	Q	GH	Q	GH	Q	GH	Q	GH	Q
Day	ft	cfs	ft	cfs	ft	cfs	ft	cfs	ft	cfs	ft	cfs
1												
2												
3												
4												30
5												
6												
7												
8												
9								43				
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												
21		121										
22												
23												
24												
25												
26												
27												
28												
29												
30								22				
31												
Tot												
Avg												
Max												
Min												

Table A.2b-4 (continued). Grant Creek – daily mean discharge (cfs), water year 1981-1982. (reproduced from Ebasco 1984)

TABLE 3.1.1 (cont.)
GRANT CREEK NEAR MOOSE PASS
MEAN DAILY DISCHARGE (C.F.S.)
Water Year October 1981 to September 1982

	Apr. 1982		May 1982		June 1982		July 1982		Aug. 1982		Sep. 1982	
Day	GH ft	Q cfs	GH ft	Q cfs	GH ft	Q cfs	GH ft	Q cfs	GH ft	Q cfs	GH ft	Q cfs
1		26			1.59	196	2.84	468	2.92	490	2.03	284
2					1.66	210	2.75	446	2.86	472	1.92	262
3					1.74	223	2.56	400	2.79	460	1.78	232
4					1.79	234	2.40	365	2.80	449	1.97	261
5					1.81	238	2.40	365	2.69	434	1.72	219
6					1.84	244	2.36	354	2.67	427	2.60	412
7					1.92	262	2.38	361	2.67	427	2.78	454
8					1.98	274	2.58	408	2.71	438	2.77	451
9					2.09	298	2.73	442	2.73	442	2.74	446
10					2.30	342	2.90	488	2.69	434	2.65	424
11					2.53	394	2.89	486	2.63	419	2.58	407
12					2.45	375	2.86	472	2.57	405	2.48	385
13					2.33	348	2.83	466	2.52	393	2.53	394
14					2.17	314	2.86	472	2.50	400	2.68	433
15					2.05	290	2.87	474	2.50	400	2.79	457
16					1.98	274	2.87	474	2.49	398	3.34	602
17					1.93	304	2.86	472	2.44	374	3.30	590
18					1.93	304	2.83	466	2.37	358	3.15	552
19					1.98	274	2.80	460	2.28	338	3.12	545
20					2.02	282	2.82	464	2.18	316	3.06	532
21				97	2.02	282	2.86	472	2.14	305	2.98	514
22				-	2.00	278	2.88	476	2.05	289	2.95	504
23				-	1.99	276	2.87	474	2.08	296	2.88	482
24			1.33	150	2.05	288	2.89	486	2.15	307	2.78	454
25			1.38	155	2.13	306	2.89	486	2.18	316	2.68	433
26			1.42	166	2.28	338	2.87	474	2.13	303	2.58	407
27			1.44	170	2.50	388	2.86	472	2.07	294	2.48	383
28			1.42	166	2.80	460	2.87	474	1.98	274	2.32	347
29			1.42	166	2.87	482	2.92	490	2.01	280	2.06	290
30			1.44	170	2.84	468	2.98	514	2.09	298	.(e)	260
31			1.50	180			2.95	505	.(e)	292		
Tot						9246		14075		11211		12372
Mean				-		308		454		371		412
Max				180		482		514		490		602
Min				-		196		354		274		212
CFsm				-		6.97		10.27		8.41		9.33
Runoff in inches				-		7.78		11.85		9.70		10.41

Table A.2b-5. Grant Creek – Daily Mean Discharge (cfs), Water Year 1982-1983. *(reproduced from Ebasco 1984)*

TABLE 3.1.1

GRANT CREEK NEAR MOOSE PASS

MEAN DAILY DISCHARGE (C.F.S.)

Water Year October 1982 to September 1983

	Oct. 1982		Nov. 1982		Dec. 1982		Jan. 1983		Feb. 1983		Mar. 1983	
Day	GH ft	Q cfs	GH ft	Q cfs	GH ft	Q cfs	GH ft	Q cfs	GH ft	Q cfs	GH ft	Q cfs
1	e*	260	1.03	103	0.98	94						
2		-	1.04	104	0.97	92						
3		-	1.02	101	0.98	94						
4		-	1.65	105	1.00	97						
5		-	1.05	105	1.07	108						
6		-	1.03	103	1.13	120						
7		-	1.02	101	1.12	118						
8		-	1.02	101	1.09	111						
9		-	1.01	99	1.07	108						
10		-	1.00	97	1.07	108						
11		-	0.98	94	1.04	104						
12		-	0.97	92	1.02	101						
13		-	0.97	92	0.99	96						
14		-	0.96	91	0.97	92						
15		-	0.95	90	0.95	90						
16		-	0.94	89	0.94	89						
17		-	0.93	87	0.99	96						
18		-	0.92	86	1.04	104						
19		-	0.91	84	1.08	110						
20		-	0.91	84	1.07	108						
21		-	0.87	77	1.06	106		46**				
22		-	0.87	77	1.04	104						
23		-	0.86	76	1.03	103						18**
24		-	0.86	76	1.02	101						
25		-	0.88	80	1.00	97						
26		-	0.94	89	e*	96						
27		-	1.02	101	e*	95						
28	1.05	105	1.02	101	e*	94						
29	1.04	104	1.01	99	e*	93						
30	1.03	103	0.99	96	e*	92						
31	1.02	101			e*	91						
Tot		-		2780		3112						
Avg		-		93		100						
Max		-		105		120						
Min		-		77		90						

*e = estimated. No gage records.
** = Discharge measurement made this date.

Table A.2b-5 (continued). Grant Creek – daily mean discharge (cfs), water year 1982-1983. *(reproduced from Ebasco 1984)*

TABLE 3.1.1 (cont.)
GRANT CREEK NEAR MOOSE PASS
MEAN DAILY DISCHARGE (C.F.S.)
Water Year October 1982 to September 1983

	Apr. 1983		May 1983		June 1983		July 1983		Aug. 1983		Sep. 1983	
Day	GH ft	Q cfs	GH ft	Q cfs	GH ft	Q cfs	GH ft	Q cfs	GH ft	Q cfs	GH ft	Q cfs
1			1.03	96	3.05	512	3.14	535	2.69	422	2.17	303
2			1.10	107	3.07	517	3.13	533	2.70	424	2.14	297
3			1.15	114	2.99	496	3.07	517	2.72	429	2.07	282
4			1.18	119	2.87	466	3.03	507	2.80	449	1.97	261
5			1.18	119	2.73	432	3.04	509	2.83	456	1.81	229
6			1.19	120	2.65	412	3.02	504	2.91	476	1.67	203
7			1.17	117	2.65	412	2.00	499	2.91	476	1.56	182
8			1.18	119	2.68	419	2.98	494	2.96	489	1.51	174
9			1.21	123	2.69	422	3.09	522	2.98	494	1.47	167
10			1.24	128	2.76	439	3.12	530	2.93	481	1.43	160
11			1.25	130	2.76	439	3.07	517	2.85	461	1.41	156
12			1.27	133	2.72	429	3.01	501	2.78	444	1.37	149
13			1.30	138	2.70	424	2.97	491	2.71	427	1.35	146
14			1.35	146	2.72	429	2.96	489	2.62	405	1.36	165
15			1.41	156	2.75	436	2.95	486	2.52	382	1.36	148
16			1.47	166	2.73	432	2.94	484	2.46	368	1.33	143
17			1.52	175	2.73	432	2.95	486	2.40	354	1.30	138
18			1.57	184	2.74	434	2.95	486	2.36	345	1.27	133
19			1.57	184	2.80	449	2.92	479	2.32	336	1.29	136
20			1.56	182	2.84	459	2.88	469	2.28	327	1.34	144
21			1.57	184	2.83	456	2.84	459	2.26	323	1.40	154
22			1.62	193	2.84	459	2.80	449	2.28	327	1.44	161
23			1.65	199	2.87	466	2.74	434	2.27	325	1.42	158
24			1.64	197	2.91	476	2.70	424	2.26	323	1.39	153
25			1.63	195	2.96	489	2.67	417	2.24	318	1.35	146
26	0.80	65	1.63	195	3.03	507	2.63	407	2.25	320	1.33	143
27	0.84	70	1.63	195	3.08	519	2.64	410	2.26	323	1.30	138
28	0.88	80	1.63	195	3.10	525	2.68	419	2.26	323	1.28	135
29	0.93	87	1.70	208	3.10	525	2.73	432	2.25	320	1.29	136
30	0.97	92	2.10	288	3.12	530	2.74	434	2.24	318	1.30	138
31			2.70	424			2.72	429	2.20	310		
Tot				5229		13842		14752		11975		5178
Avg				169		461		476		386		173
Max				288		530		535		494		303
Min				96		412		407		310		135

Table A.2b-6. Grant Creek – daily mean discharge (cfs), water year 1983-1984. *(reproduced from Ebasco 1984)*

TABLE 3.1.1 (cont.)

GRANT CREEK NEAR MOOSE PASS

MEAN DAILY DISCHARGE (C.F.S.)

Water Year October 1983 to September 1984

	Oct. 1983		Nov. 1983		Dec. 1983		Jan. 1984		Feb. 1984		Mar. 1984	
Day	GH ft	Q cfs	GH ft	Q cfs	GH ft	Q cfs	GH ft	Q cfs	GH ft	Q cfs	GH ft	Q cfs
1	1.29	136	1.12	110	1.30	138						
2	1.28	135	1.14	113	1.32	141						
3	1.27	133	1.17	117	1.31	140						
4	1.25	130	1.15	114	1.27	133						
5	1.23	127	1.14	113	1.24	128						
6	1.20	122	1.13	111	1.20	122						
7	1.17	117	1.13	111	1.16	116						
8	1.15	114	1.14	113								
9	1.14	113	1.14	113								
10	1.17	117	1.21	124								
11	1.26	131	1.24	128								
12	1.31	139	1.24	128								
13	1.31	139	1.21	124								
14	1.29	136	1.18	119								
15	1.27	133	1.17	117								
16	1.25	130	1.14	113								
17	1.23	127	1.13	111								
18	1.24	128	1.09	105								
19	1.24	128	1.07	102								
20	1.21	123	1.04	98								
21	1.23	127	1.02	95								
22	1.27	133	1.01	94								
23	1.28	135	1.00	92								
24	1.27	133	0.98	89								
25	1.24	128	0.97	88								
26	1.21	123	0.96	87								
27	1.19	120	0.94	84								
28	1.20	122	0.97	88								
29	1.18	119	1.03	96								
30	1.16	116	1.24	128								
31	1.14	113										
Tot		3806		3235								
Avg		123		108								
Max		139		128								
Min		113		84								

[This page intentionally left blank.]

Appendix 3: Grant Lake Dissolved Oxygen Profiles

This appendix contains the following figures and tables:

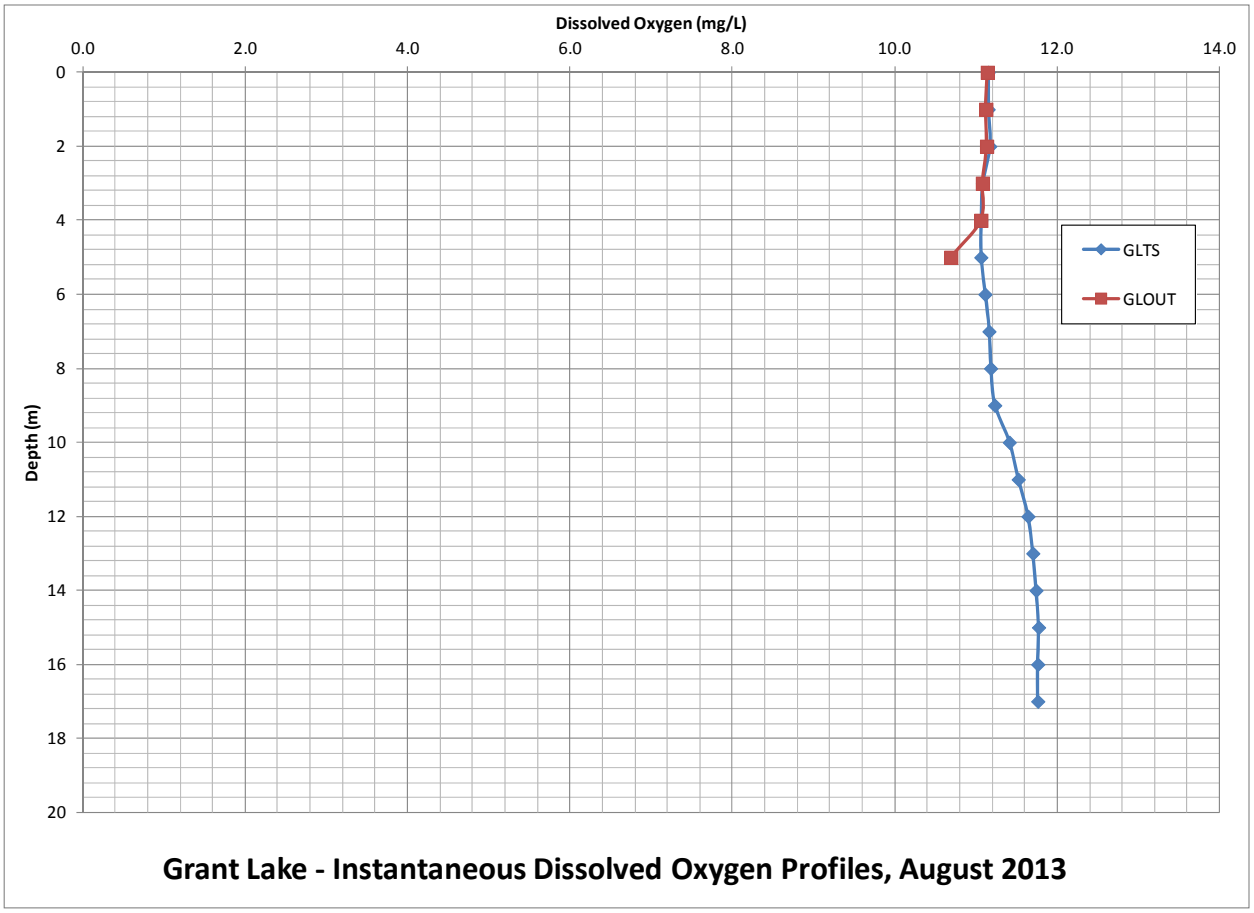


Figure A.3-1. Grant Lake – dissolved oxygen profiles (mg/L), 2013.

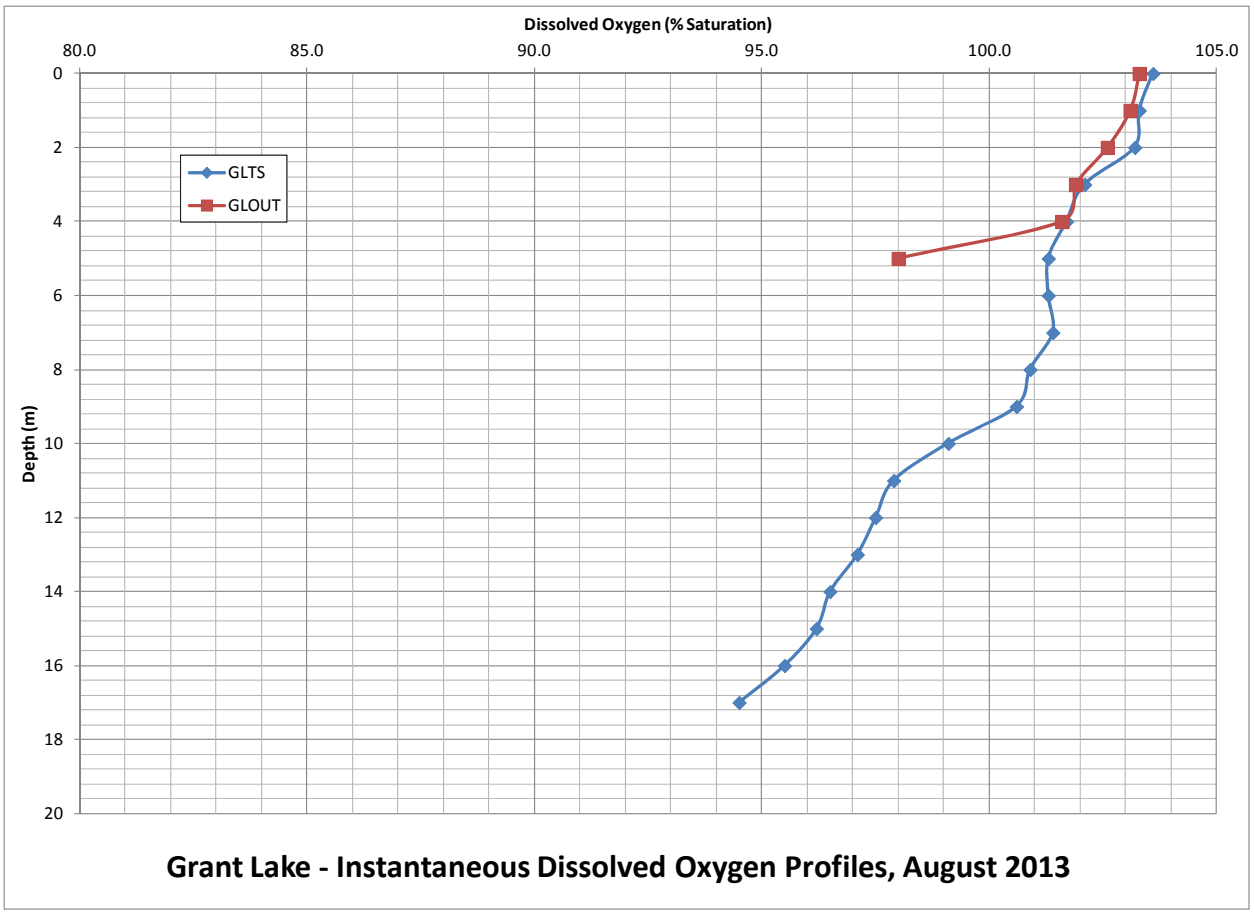


Figure A.3-2. Grant Lake – Dissolved oxygen profiles (% saturation), 2013.

Table A.3-1. Grant Lake – dissolved oxygen profiles (mg/L), 1981-1982. *(reproduced from Ebasco 1984)*

TABLE 2-9

DISSOLVED OXYGEN MEASUREMENTS FOR GRANT LAKE

Depth (m)	Depth (ft)	Dissolved Oxygen (mg/l) June 1981[a] Lower Basin	June 1981[a] Upper Basin	October 1981[b] Lower Basin	October 1981[b] Upper Basin	June 1982[b] Lower Basin	June 1982[b] Upper Basin
Surface		11.3	11.6	10.75	10.5	14	14.5
1	3.3	11.5	11.8			13.5	
2	6.6	11.7	11.9			13.5	
3	9.9	11.8	12.0			13.5	
4	13.1	11.8	12.0			13.5	
5	16.4	11.9	12.1			13.5	
6	19.7	11.9	12.0			13.5	
7	23.0	12.0	11.8			13.5	
8	26.2	12.1	11.9			13.5	
9	29.5	12.1	12.0			13.5	
10	32.8	12.1	11.9			13.5	
15	49.2	12.2	12.4			12.9	
20	65.6	12.1	12.3			12.5	
25	82.0	12.2				12.5	
30	98.4	12.0	12.6			12.4	
35	114.8					12.4	
40	131.2	12.0	12.6			12.0	
45	147.6					11.8	
50	164.0	11.9	12.6			11.0	
52	170.6			9.75		10.8	
54	177.2				10.25		
60	196.9		12.6				

a/ Source: ADF&G 1981

b/ Source: AEIDC 1982

[This page intentionally left blank.]